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ABSTRACT

The rate training manual is one of a series of training manuals prepared for enlisted personnel of the Navy and Naval Reserve studying for advancement from the Aviation Machinist's Mate ADJ2 rating to ADJ1 to ADJC. Aviation Machinist's Mates J maintain aircraft jet engines and their related systems. Chpater 1 discusses the enlisted rating structure, the ADJ rating, and information which would be helpful in preparing for advancement. Chapters 2-10 cover the following topics: aviation supply, work center supervision and administration, Jetcal analyzer, fuel system maintenance, turbojet powerplant troubleshooting, turbojet powerplant removal and installation, turbojet powerplant hot section repair, turboshaft-powered helicopter maintenance, and turbojet powerplants/propellers. Numerous illustrations, diagrams, and charts are interspersed throughout the document. A subject index is included. (Author/BP)

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AVIATION

MACHINIST'S MATE J 1 & C

NAVAL TRAINING COMMAND

RATE TRAINING MANUAL

NAVTRA 10343-C

PREFACE

This Rate Training Manual is one of a series of training manuals prepared for enlisted personnel of the Navy and Naval Reserve who are studying for advancement in the Aviation Machinist's Mate J rating. As indicated by the title, the manual is based on the professional qualifications for the rates of ADJ1 and ADJC, as set forth in the Manual of Qualifications for Advancement, NavPers 18068 (Series).

This training manual was prepared by the Navy Training Publications Center, Naval Air Station, Memphis, Millington, Tennessee, for the Chief of Naval Training Support. Technical review of the manuscript was provided by personnel of the Aviation Machinist's Mate School, NATTC, Naval Air Station, Memphis, Millington, Tennessee, and the Naval Examining Center, Great Lakes, Illinois. Technical assistance was also provided by the Naval Air Systems Command.

1972 Edition

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THE UNITED STATES NAVY

GUARDIAN OF OUR COUNTRY

The United States Navy is responsible for maintaining control of the sea and is a ready force on watch at home and overseas, capable of strong action to preserve the peace or of instant offensive action to win in war.

It is upon the maintenance of this control that our country's glorious future depends; the United States Navy exists to make it so.

WE SERVE WITH HONOR

Tradition, valor, and victory are the Navy's heritage from the past. To these may be added dedication, discipline, and vigilance as the watchwords of the present and the future.

At home or on distant stations we serve with pride, confident in the respect of our country, our shipmates, and our families.

Our responsibilities sober us; our adversities strengthen us.

Service to God and Country is our special privilege. We serve with honor.

THE FUTURE OF THE NAVY

The Navy will always employ new weapons, new techniques, and greater power to protect and defend the United States on the sea, under the sea, and in the air.

Now and in the future, control of the sea gives the United States her greatest advantage for the maintenance of peace and for victory in war.

Mobility, surprise, dispersal, and offensive power are the keynotes of the new Navy. The roots of the Navy lie in a strong belief in the future, in continued dedication to our tasks, and in reflection on our heritage from the past.

Never have our opportunities and our responsibilities been greater.

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READING LIST

USAFI TEXTS

United States Armed Forces Institute (USAFI) courses for additional reading and study are available through your Educational Services Officer.* The following courses are recommended:

C710 Jet Aircraft Engines
D700 General Aeronautics

*"Members of the United States Armed Forces Reserve components, when on active duty, are eligible to enroll for USAFI courses, services, and material if the orders calling them to active duty specify a period of 120 days or more.

CHAPTER 1

AVIATION MACHINIST'S MATE J RATING

This training manual is designed to aid the ADJ2 in preparing for advancement to ADJ1 and the ADJ1 in preparing for advancement to ADJC. It is based primarily on the professional requirements or qualifications for ADJ1 and ADJC, as specified in the current edition of the Manual of Qualifications for Advancement, NavPers 18068. In preparing for advancement examinations, this manual should be studied in conjunction with Military Requirements for Petty Officer 1 & C, NavPers 10057 (Series).

In preparing this training manual, every effort has been made to cover professional matters adequately and yet within reasonable bounds. It has been designed to give the prospective ADJ1 and ADJC a good working knowledge of all subjects covered by the professional qualifications for advancement. It includes some new material required as a result of new or revised maintenance programs and qualification changes.

It should be kept in mind that any change in the professional qualifications occurring after the June 1972 revision of the "Quals" Manual may not be reflected in the information given in this manual.

The remainder of this chapter is devoted to information which should be helpful in preparing for advancement. It is strongly recommended that this material be studied carefully before beginning intensive study of the remainder of the manual.

ENLISTED RATING STRUCTURE

The present enlisted rating structure includes two types of ratings: general ratings and service ratings.

GENERAL RATINGS are designed to provide paths of advancement and career development. A general rating identifies a broad occupational field of related duties and functions requiring similar aptitudes and qualifications. General ratings provide the primary means used to identify billet requirements and personnel qualifications. Some general ratings include service ratings; others do not. Both Regular Navy and Naval Reserve personnel may hold general ratings.

Subdivisions of certain general ratings are identified as SERVICE RATINGS. These service ratings identify areas of specialization within the scope of a general rating. Service ratings are established in those general ratings in which specialization is essential for efficient utilization of personnel. Although service ratings can exist at any petty officer level, they are most common at the PO3 and PO2 levels. Both Regular Navy and Naval Reserve personnel may hold service ratings.

ADJ RATING

The Aviation Machinist's Mate rating is composed of two service ratings and one general rating. The service ratings are Aviation Machinist's Mate J (ADJ) and Aviation Machinist's Mate R (ADR). The two service ratings apply to personnel in pay grades E-4 through E-7. The general rating is known simply as the Aviation Machinist's Mate rating and applies only to pay grade E-8 (ADCS). At pay grade E-9 the AD rating loses its identity and the ADCS advances, along with the AMCS to Master Chief Aircraft Maintenanceman (AFCM). Figure 1-1 illustrates the paths of advancement from Recruit to Master Chief Aircraft Maintenanceman (AFCM), Warrant Officer (W-4), and Limited Duty Officer.

Shaded areas in figure 1-1 indicate places in the enlisted path of advancement where qualified personnel may advance to Warrant Officer (W-1), and selected Commissioned Warrant Officers (W-2 and W-3) may advance to Limited Duty Officer. Personnel in enlisted rates and Warrant

ranks not in a shaded area (fig. 1-1) may advance only as indicated by the connecting arrows. Additional information concerning promotion to Warrant and Commissioned Officer is presented later in this chapter.

Aviation Machinist's Mates J maintain aircraft jet engines and their related systems including the induction, cooling, fuel, oil, compression, combustion, turbine, and exhaust systems; preflight aircraft; conduct periodic inspections on jet engines and related systems; remove, repair, and replace compressor and turbine blades and combustion chamber liners; assemble and disassemble aircraft propellers; rig and adjust propeller control mechanisms; preserve and depreserve jet engines, engine accessories, and components; and supervise jet engine work centers.

In addition to the above listed requirements, the Chief and First Class Aviation Machinist's Mate J must be qualified to supervise and direct periodic inspections; maintain logs and records and prepare reports; order and identify publications, identify and order aircraft parts, tools, and equipment; maintain current shop files of directives and other publications; maintain inventory records; use schematic diagrams, drawings, and charts in troubleshooting and correcting powerplant system and propeller malfunctions; interpret and verify input source documents to the 3-M system; read and interpret daily and monthly MDR and MHA reports; review and evaluate completed inspection forms and reports; analyze reports of discrepancies and malfunctions and determine corrective action; organize and administer a program of safety instructions applicable to aircraft powerplants, propellers, and related systems; supervise the manhour accounting program; interpret directives from higher authorities; schedule and assign workload; and maintain the highest possible state of quality work for which the ADJ is responsible.

A wide variety of assignments is available to the ADJ1 and ADJC. In addition to the various types of maintenance activities ashore and afloat to which ADJ personnel are assigned, the ADJ1 and ADJC are eligible for assignment to instructor duty as well as a number of other desirable shore billets. Most of these billets are under the management control of BuPers and are directly associated with research, testing, or evaluation. Some of the more desirable billets to which the ADJ1 and ADJC may be assigned are described in the following paragraphs.

1. Instructor duty is available to both the ADJ1 and ADJC at NATTC, Millington, Tennessee, in all AD schools. In addition to the AD schools, the ADJ1 and ADJC may be assigned to instructor duty with a unit of the Naval Air Maintenance Training Group (NAMTG). Units of NAMTG are located at shore stations on both coasts. Personnel assigned to this duty are first sent to Naval Air Maintenance Training Group Headquarters at Millington, Tennessee, for a period of indoctrination and instruction prior to being assigned to one of the many units.

Instructor billets are normally filled on a voluntary basis. Detailed information concerning assignment to instructor duty is contained in the Enlisted Transfer Manual, NavPers 15909 (Series).

2. Chief Aviation Machinist's Mates are eligible for assignment to duty with the Navy Training Pulbications Center (NTPC) NAS Memphis, Millington, Tennessee, as Technical Writers. CPO's assigned to NTPC billets assist in the preparation and revision of Rate Training Manuals (such as this training manual) for the Group IX ratings.

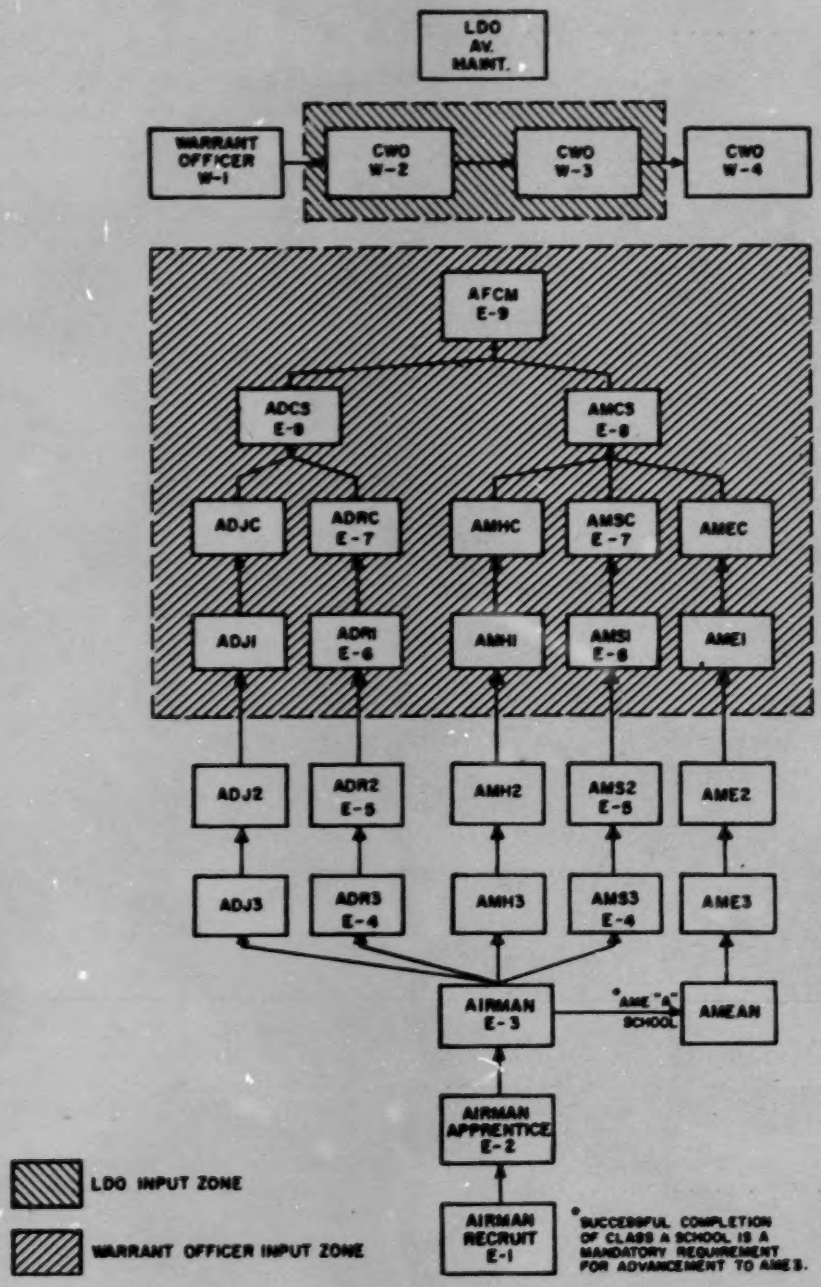
3. Chief Aviation Machinist's Mates are also eligible for assignment to duty with the Naval Examining Center, Great Lakes, Illinois, as Item Writers. CPO's assigned to billets at the Examining Center assist in the preparation of servicewide advancement examinations for enlisted personnel.

4. From time to time recruiting duty billets are available to both the ADJ1 and ADJC. These billets are located in various towns and cities throughout this country and in some possessions.

5. Attache duty is another possibility. This duty may be performed at numerous places throughout the world.

There are a number of special programs and projects to which enlisted personnel may be assigned. Some of these involve research, others may involve testing or evaluation. An example of such an assignment is with the Personnel Research Division (PRD), Naval Aviation Integrated Logistic Support Center (NAILSC), NAS Patuxent River, Maryland. Their mission is to develop recommended personnel requirements for squadrons operating and maintaining the latest types of weapon systems.

For a listing of other special programs, reference should be made to the Enlisted Transfer Manual. Others are also announced from time to time in BuPers Notices..



AM. 1

Figure 1-1.—Paths of advancement.

Personnel may indicate their desire for assignment to a specific program or project by indicating it in the "remarks" block of their Rotation Data Card.

As a petty officer, you are already aware of the vast importance of the ADJ rating to naval aviation. Pilots and aircrewmen depend upon the ADJ for the efficient operation of the aircraft. As aviation progresses, improved powerplants must be developed. Thus, the ADJ's job involves new and greater responsibilities; and from the lowest level up, he must possess greater skills than ever before.

When advanced to ADJ1 and ADJC, even more responsibilities are to be yours. As a senior petty officer, you must possess more than technical skills. You must assume greater responsibilities not only for your own work, but also for the work of others who serve under you. Briefly, the ADJ1 and ADJC must be skilled mechanics, supervisors, inspectors, and instructors, as well as accomplished military leaders. Senior petty officers are therefore vitally concerned with the Naval Leadership Program.

As a result of the Naval Leadership Program a considerable amount of material related to naval leadership for the senior petty officer is available. Studying this material will make you aware of your many leadership responsibilities as a senior petty officer and will also be of great help in developing leadership qualities. It will not in itself, however, make you a good leader. Leadership principles can be taught, but a good leader acquires that quality only through hard work and practice.

As you study this material containing leadership traits, keep in mind that probably none of our most successful leaders possessed all of these traits to a maximum degree, but a weakness in some traits was more than compensated for by strength in others. Critical self-evaluation will enable you to realize the traits in which you are strong, and to capitalize on them. At the same time you must strive to improve on the traits in which you are weak.

Your success as a leader will be decided, for the most part, by your achievements in inspiring others to learn and perform. This is best accomplished by personal example.

ADVANCEMENT

By this time, you are probably well aware of the personal advantages of advancement—higher pay, greater prestige, more interesting and challenging work, and the satisfaction of getting ahead in your chosen career. By this time, also you have probably discovered that one of the most enduring rewards of advancement is the training you acquire in the process of preparing for advancement.

The Navy also profits by your advancement. Highly trained personnel are essential to the functioning of the Navy. By advancement, you increase your value to the Navy in two ways; First, you become more valuable as a technical specialist, and thus make far-reaching contributions to the entire Navy; and second, you become more valuable as a person who can supervise, lead, and train others.

Since you are studying for advancement to PO1 or CPO, you are probably already familiar with the requirements and procedures for advancement. However, you may find it helpful to read the following sections. The Navy does not stand still. It is possible that some of the requirements have changed since the last time you went up for advancement. Furthermore, you will be responsible for training others for advancement; therefore, you will need to know the requirements in some detail.

HOW TO QUALIFY FOR ADVANCEMENT

To qualify for advancement, a person must:

1. Have a certain amount of time in grade.
2. Complete the required Rate Training Manuals either by demonstrating a knowledge of the material in the manual by passing a locally prepared and administered test or by passing the Enlisted Correspondence Course based on the Rate Training Manual.
3. Utilizing an appropriate Personnel Qualification Standard (when applicable) as a guideline, become qualified and demonstrate your ability to perform all the practical requirements for advancement by completing the Record of Practical Factors, NavPers 1414/1.
4. Be recommended by his commanding officer, after the petty officers and officers supervising the work have indicated that they consider him capable of performing the duties of the next higher rate.
5. Demonstrate KNOWLEDGE by passing a written examination on (a) military requirements, and (b) professional qualifications.

Some of these general requirements may be modified in certain ways. Figure 1-2 gives an

overall view of the requirements for advancement of active duty personnel; figure 1-3 gives this information for inactive duty personnel.

Remember that the requirements for advancement can change. Check with your educational services office to be sure that you know the most recent requirements.

When you are training lower rated personnel, it is a good idea to point out that advancement is not automatic. Meeting all the requirements makes a person ELIGIBLE for advancement, but it does not guarantee his advancement. Such factors as the score made on the written examination, length of time in service, performance marks, and quotas for the rating enter into the final determination of who will actually be advanced.

HOW TO PREPARE FOR ADVANCEMENT

What must you do to prepare for advancement? You must study the qualifications for advancement, work on the practical factors, study the required Rate Training Manuals, and study other material that is required. You will need to be familiar with the following:

1. Manual of Qualifications for Advancement, NavPers 18068 (Series).
2. Record of Practical Factors, NavPers 1414/1.
3. Bibliography for Advancement Study, NavTra 10052 (Series).
4. Applicable Rate Training Manuals and their companion Enlisted Correspondence Courses.

Collectively, these documents make up an integrated training package tied together by the qualifications. The following paragraphs describe these materials and give some information on how each one is related to the others.

"Quals" Manual

The Manual of Qualifications for Advancement, NavPers 18068 (Series), gives the minimum requirements for advancement to each rate within each rating. This manual is usually called the "Quals" Manual, and the qualifications themselves are often called "quals." The qualifications are of two general types: (1) military requirements, and (2) professional or technical qualifications. Military requirements apply to all ratings rather than to any one rating alone. Professional qualifications are technical or professional requirements that are directly related to the work of each rating.

Both the military requirements and the professional qualifications are divided into subject matter groups. Then, within each subject matter group, they are divided into PRACTICAL FACTORS and KNOWLEDGE FACTORS.

The qualifications for advancement and a bibliography of study materials are available in your educational services office. The "Quals" Manual is changed more frequently than Rate Training Manuals are revised. By the time you are studying this training manual, the "quals" for your rating may have been changed. Never trust any set of "quals" until you have checked the change number against an UP-TO-DATE copy of the "Quals" Manual.

In training others for advancement, emphasize these three points about the "quals";

1. The "quals" are the MINIMUM requirements for advancement. Personnel who study MORE than the required minimum will have a great advantage when they take the written examinations for advancement.
2. Each "qual" has a designated rate level—chief, first class, second class, or third class. You are responsible for meeting all "quals" specified for the rate level to which you are seeking advancement AND all "quals" specified for lower rate levels. This manual is written to provide additional or add-on information to that contained in ADJ 3 &2, NavPers 10341-B, and it is recommended that the material in this 3 & 2 manual be reviewed.
3. The written examinations for advancement will contain questions relating to the practical factors AND to the knowledge factors of BOTH the military requirements and the professional qualifications.

Record of Practical Factors

Before you can take the Navy-wide examination for advancement, there must be an entry in your service record to show that you have qualified in the practical factors of both the military requirements and the professional qualifications. A special form known as the Record of Practical Factors, NavPers 1414/1 (plus the abbreviation of the appropriate rating), is used to keep a record of your practical factor qualifications. The form lists all practical factors, both military and professional. As you demonstrate your ability to perform each practical factor,

REQUIREMENTS*	E1 to E2	E2 to E3	#1 E3 to E4	#E4 to E5	† E5 to E6	† E6 to E7	† E7 to E8	† E8 to E9
SERVICE	4 mos. service—or completion of	6 mos. as E-2.	6 mos. as E-3	12 mos. as E-4	24 mos. as E-5.	36 mos. as E-6. 8 years total enlisted service.	36 mos as E-7. 8 of 11 years total service must be enlisted.	24 mos. as E-8. 10 of 12 years total service must be enlisted.
SCHOOL	Recruit Training.		Class A for PR3, DT3, PT3, AME 3, HM 3, PN 3, FTB 3, MT 3.			Class B for AGC MUC, MNC. ††		
PRACTICAL FACTORS	Locally prepared check-offs.	Record of Practical Factors, NavPers 1414/1, must be completed for E-3 and all PO advancements.						
PERFORMANCE TEST			Specified ratings must complete applicable performance tests before taking examinations.					
ENLISTED PERFORMANCE EVALUATION	As used by CO when approving advancement.	Counts toward performance factor credit in advancement multiple.						
EXAMINATIONS**	Locally prepared tests.	See below.	Navy-wide examinations required for all PO advancements.				Navy-wide, selection board.	
RATE TRAINING MANUAL (INCLUDING MILITARY REQUIREMENTS)		Required for E-3 and all PO advancements unless waived because of school completion, but need not be repeated if identical course has already been completed. See NavPers 10052 (current edition).					Correspondence courses and recommended reading. See NavPers 10052 (current edition).	
AUTHORIZATION	Commanding Officer	Naval Examining Center						

* All advancements require commanding officer's recommendation.

† 1 year obligated service required for E-5 and E-6; 2 years for E-7, E-8 and E-9.

Military leadership exam required for E-4 and E-5.

** For E-2 to E-3, NAVEXAMCEN exams or locally prepared tests may be used.

†† Waived for qualified EOD personnel.

Figure 1-2.—Active duty advancement requirements.

REQUIREMENTS *	E1 to E2	E2 to E3	E3 to E4	E4 to E5	E5 to E6	E6 to E7	E8	E9
TOTAL TIME IN GRADE	4 mos.	6 mos.	6 mos.	12 mos.	24 mos.	36 mos. with total 8 yrs service	36 mos with total 11 yrs service	24 mos. with total 13 yrs service
TOTAL TRAINING DUTY IN GRADE †	14 days	14 days	14 days	14 days	28 days	42 days	42 days	28 days
PERFORMANCE TESTS		Specified ratings must complete applicable performance tests before taking examination.						
DRILL PARTICIPATION	Satisfactory participation as a member of a drill unit in accordance with BUPERSINST 5400.42 series.							
PRACTICAL FACTORS (INCLUDING MILITARY REQUIREMENTS)	Record of Practical Factors, NavPers 1414/1, must be completed for all advancements.							
RATE TRAINING MANUAL (INCLUDING MILITARY REQUIRE MENTS)	Completion of applicable course or courses must be entered in service record.							
EXAMINATION	Standard Exam	Standard Exam required for all PO Advancements. Also pass Military Leadership Exam for E-4 and E-5.					Standard Exam, Selection Board.	
AUTHORIZATION	Commanding Officer	Naval Examining Center						

* Recommendation by commanding officer required for all advancements.

† Active duty periods may be substituted for training duty.

Figure 1-3.—Inactive duty advancement requirements.

appropriate entries are made in the DATE and INITIALS columns.

As a PO1 or CPO, you will often be required to check the practical factor performance of lower rated personnel and to report the results to your supervising officer.

As changes are made periodically to the "Quals" Manual, new forms of NavPers 1414/1 are provided when necessary. Extra space is allowed on the Record of Practical Factors for entering additional practical factors as they are published in changes to the "Quals" Manual. The Record of Practical Factors also provides space for recording demonstrated proficiency in skills which are within the general scope of the rating but which are not identified as minimum qualifications for advancement. Keep this in mind when you are training and supervising other personnel. If a person demonstrates proficiency in some skill which is not listed in the "quals" but which is within the general scope of the rating, report this fact to the supervising officer so that an appropriate entry can be made in the Record of Practical Factors.

When you are transferred, the Record of Practical Factors should be forwarded with your service record to your next duty station. It is a good idea to check and be sure that this form is actually inserted in your service record before you are transferred. If the form is not in your record, you may be required to start all over again and requalify in practical factors that have already been checked off. You should also take some responsibility for helping lower rated personnel keep track of their practical factor records when they are transferred.

A second copy of the Record of Practical Factors should be made available to each man in pay grades E-2 through E-8 for his personal record and guidance.

The importance of NavPers 1414/1 cannot be overemphasized. It serves as a record to indicate to the petty officers and officers supervising your work that you have demonstrated proficiency in the performance of the indicated practical factors and is part of the criteria utilized by your commanding officer when he considers recommending you for advancement. In addition, the proficient demonstration of the applicable practical factors listed on this form can aid you in preparing for the examination for advancement. Remember that the knowledge aspects of the practical factors are covered in the examination for advancement. Certain knowledge is required to demonstrate these practical factors and additional knowledge can be acquired during the demonstration. Knowledge factors pertain to that knowledge which is required to perform a certain job. In other words, the knowledge factors required for a certain rating depend upon the jobs (practical factors) that must be performed by personnel of that rating. Therefore, the knowledge required to proficiently demonstrate these practical factors will definitely aid you in preparing for the examination for advancement.

Personnel Qualification Standards

Personnel Qualification Standards (PQS) are presently being developed to provide guidelines in preparing for advancement and qualification to operate specific equipment and systems. They are designed to support the advancement requirements as stated in the "Quals" Manual.

The "Quals" and Record of Practical Factors are stated in broad terms. Each PQS is much more specific in its questions that lead to qualification. It provides an analysis of specific equipment and duties, assignments, or responsibilities which an individual or group of individuals (within the same rating) may be called upon to carry out. In other words, each PQS provides an analysis of the complete knowledge and skills required of that rating tied to a specific weapon system (aircraft and/or individual systems or components).

Each qualification standard has four main subdivisions in addition to an introduction and a glossary of PQS terms. They are as follows:

100 Series—Theory.
200 Series—Systems.
300 Series—Watchstations (duties, assignments, or responsibilities).
400 Series—Qualification cards.

The introduction explains the complete use of the qualification standard in terms of what it will mean to the user as well as how to use it.

The Theory (100 Series) section specifies the theory background required as a prerequisite to the commencement of study in the specific equipment or system for which the PQS was written. These fundamentals are normally taught in the formal schools (Preparatory, Fundamentals, and Class A) phase of an individual's training. However, if the individual has not been to school, the requirements are outlined and referenced to provide guidelines for a self-study program.

The Systems (200 Series) section breaks down the equipment or systems being studied into

functional sections. PQS items are essentially questions asked in clear, concise statement (question) form and arranged in a standard format. The answers to the questions must be extracted from the various maintenance manuals covering the equipment or systems for which the PQS was written. This section asks the user to explain the function of the system, to draw a simplified version of the system from memory, and to use this drawn schematic or the schematic provided in the maintenance manual while studying the system or equipment. Emphasis is given to such areas as maintenance management procedures, components, component parts, principles of operation, system interrelations, numerical values considered necessary to operation and maintenance, and safety precautions.

The Watchstation (300 series) section includes questions regarding the procedures the individual must know to operate and maintain the equipment or system. A study of the items in the 200 series section provides the individual with the required information concerning what the system or equipment does, how it does it, and other pertinent aspects of operation. In the 300 series section, the questions advance the qualification process by requiring answers or demonstrations of ability to put this knowledge to use or to cope with maintaining of the system or equipment. Areas covered include normal operation; abnormal or emergency operation; emergency procedures which could limit damage and/or casualties associated with a particular operation; operation that occur too infrequently to be considered mandatory performance items; and maintenance procedures/instructions such as checks, tests, repair, replacement, etc.

The 400 series section consists of the qualification cards. These cards are the accounting documents utilized to record the individual's satisfactory completion of items necessary for becoming qualified in duties assigned. Where the individual starts in completing a standard will depend on his assignment within an activity. The complete PQS is given to the individual being qualified so that he can utilize it at every opportunity to become fully qualified in all areas of his rating and the equipment or system for which the PQS was written. Upon transfer to a different activity, each individual must requalify. The answers to the questions asked in the qualification standards may be given orally or in writing to the supervisor, the branch or division officer, and maintenance officer as required to certify proper qualification. The completion of part or all of the PQS provides a basis for the supervising petty officer and officer to certify completion of Practical Factors for Advancement.

NavTra 10052

Bibliography for Advancement Study, NavTra 10052 (Series) is a very important publication for anyone preparing for advancement. This publication/bibliography lists required and recommended Rate Training Manuals and other reference material to be used by personnel working for advancement. NavTra 10052 (Series) is revised and issued once each year by the Naval Training Command. Each revised edition is identified by a letter following the NavTra number; be sure you have the most recent edition.

The required and recommended references are listed by rate level in NavTra 10052 (Series). It is important to remember that you are responsible for all references at lower rate levels, as well as those listed for the rate to which you are seeking advancement.

Rate Training Manuals that are marked with an asterisk (*) in NavTra 10052 (Series) are MANDATORY at the indicated rate levels. A mandatory training manual may be completed by (1) passing the appropriate Enlisted Correspondence Course that is based on the mandatory training manual; (2) passing locally prepared tests based on the information given in the mandatory training manual; or (3) in some cases, successfully completing an appropriate Navy School.

When training personnel for advancement, do not overlook the section of NavTra 10052 (Series) which lists the required and recommended references relating to the military requirements for advancement. All personnel must complete the mandatory military requirements training manual for the appropriate rate level before they can be eligible to advance. Also, make sure that personnel working for advancement study the references listed as recommended but not mandatory in NavTra 10052 (Series). It is important to remember that ALL references listed in NavTra 10052 (Series) may be used as source material for the written examinations, at the appropriate levels.

Rate Training Manuals

There are two general types of Rate Training Manuals. Rate Training Manuals (such as this

one) are prepared for most enlisted rates and ratings, giving information that is directly related to the professional qualifications for advancement. Subject matter manuals give information that applies to more than one rating.

Rate Training Manuals are produced by field activities under the management control of the Naval Training Command. Manuals are revised from time to time to keep them up to date technically. The numbering system is being changed from NavPers to NavTra. The revision of a Rate Training Manual is identified by a letter following the NavPers or NavTra number. You can tell whether any particular copy of a Rate Training Manual is the latest edition by checking the number in the most recent edition of List of Training Manuals and Correspondence Courses, NavTra 10061 (Series). NavTra 10061 is actually a catalog that lists current training manuals and correspondence courses; you will find this catalog useful in planning your study program.

Rate Training Manuals are designed for the special purpose of helping naval personnel prepare for advancement. By this time, you have probably developed your own way of studying these manuals. Some of the personnel you train, however, may need guidance in the use of Rate Training Manuals. Although there is no single "best" way to study a training manual, the following suggestions have proved useful for many people:

1. Study the military requirements and the professional qualifications for your rate before you study the training manual, and refer to the "quals" frequently as you study. Remember, you are studying the training manual primarily to meet these "quals."

2. Set up a regular study plan, if possible, schedule your studying for a time of day when you will not have too many interruptions or distractions.

3. Before you being to study any part of the training manual intensively, get acquainted with the entire manual. Read the preface and the table of contents. Check through the index. Thumb through the manual without any particular plan, looking at the illustrations and reading bits here and there as you see things that interest you.

4. Look at the training manual in more detail, to see how it is organized. Look at the table of contents again. Then, chapter by chapter, read the introduction, the headings, and the subheadings. This will give you a clear picture of the scope and content of the manual.

5. When you have a general idea of what is in the training manual and how it is organized, fill in the details by intensive study. In each study period, try to cover a complete unit—it may be a chapter, a section of a chapter, or a subsection. The amount of material you can cover at one time will vary. If you know the subject well, or if the material is easy, you can cover quite a lot at one time. Difficult or unfamiliar material will require more study time.

6. In studying each unit, write down questions as they occur to you. Many people find it helpful to make a written outline of the unit as they study, or at least to write down the most important ideas.

7. As you study, relate the information in the training manual to the knowledge you already have. When you read about a process, a skill, or a situation, ask yourself some questions. Does this information tie in with past experience? Or is this something new and different? How does this information relate to the qualifications for advancement?

8. When you have finished studying a unit, take time out to see what you have learned. Look back over your notes and questions. Maybe some of your questions have been answered, but perhaps you still have some that are not answered. Without referring to the training manual, write down the main ideas you have learned from studying this unit. Do not just quote the manual. If you cannot give these ideas in your own words, the chances are that you have not really mastered the information.

9. Use Enlisted Correspondence Courses whenever you can. The correspondence courses are based on Rate Training Manuals or other appropriate texts. As mentioned before, completion of a mandatory Rate Training Manual can be accomplished by passing an Enlisted Correspondence Course based on the training manual. You will probably find it helpful to take other corresponce courses, as well as those based on mandatory training manuals. Taking a correspondence course helps you to master the information given in the training manual, and also gives you an idea of how much you have learned.

10. You should note than occasionally reference is made in the Rate Training Manual to publications which contain information relative to the rating, but which are not listed in NavTra 10052 (Series). These are known as secondary references and should be reviewed in conjunction with your study of the Rate Training Manual to better prepare yourself for advancement.

INCREASED RESPONSIBILITIES

When you assumed the duties of a PO3, you began to accept a certain amount of responsibility for the work of others. With each advancement, you accept an increasing responsibility in military matters and in matters relating to the professional work of your rate. When you advance to PO1 or CPO, you will find a noticeable increase in your responsibilities for leadership, supervision, training, working with others, and keeping up with new developments.

As your responsibilities increase, your ability to communicate clearly and effectively must also increase. The simplest and most direct means of communication is a common language. The basic requirement for effective communication is therefore a knowledge of your own language. Use correct language in speaking and in writing. Remember that the basic purpose of all communication is understanding. To lead, supervise, and train others, you must be able to speak and write in such a way that others can understand exactly what you mean.

Leadership and Supervision

As a PO1 or CPO, you will be regarded as a leader and supervisor. Both officers and enlisted personnel will expect you to translate the general orders given by officers into detailed, practical, on-the-job language that can be understood and followed by relatively inexperienced personnel. In dealing with your juniors, it is up to you to see that they perform their jobs correctly. At the same time, you must be able to explain to officers any important problems or needs of enlisted personnel. In all military and professional matters, your responsibilities will extend both upward and downward.

Along with your increased responsibilities, you will also have increased authority. Officers and petty officers have POSITIONAL authority—that is, their authority over others lies in their positions. If your CO is relieved, for example, he no longer has the degree of authority over you that he had while he was your CO, although he still retains the military authority that all seniors have over subordinates. As a PO1, you will have some degree of positional authority; as a CPO, you will have even more. When exercising your authority, remember that it is positional—it is the rate you have, rather than the person you are, that gives you this autority.

A Petty Officer conscientiously and proudly exercises his authority to carry out the responsibilities he is given. He takes a personal interest in the success of both sides of the chain of command . . . authority and responsibility. For it is true that the Petty Officer who does not seek out and accept responsibility, loses his authority and then the responsibility he thinks he deserves. He must be sure, by his example and by his instruction, that the Petty Officers under him also accept responsibility. In short, he must be the leader his title—Petty Officer—says he is.

Training

As a PO1 or CPO, you will have regular and continuing responsibilities for training others. Even if you are lucky enough to have a group of subordinates who are all highly skilled and well trained, you will still find that training is necessary. For example, you will always be responsible for training lower rated personnel for advancement. Also, some of your best workers may be transferred; and inexperienced or poorly trained personnel may be assigned to you. A particular job may call for skills that none of your personnel have. These and similar problems require that you be a training specialist—one who can conduct formal and informal training programs to qualify personnel for advancement, and one who can train individuals and groups in the effective execution of assigned tasks.

In using this training manual, study the information from two points of view. First, what do you yourself need to learn from it? And second, how would you go about teaching this information to others?

Training goes on all the time. Every time a person does a particular piece of work, some learning is taking place. As a supervisor and as a training expert, one of your biggest jobs is to see that your personnel learn the RIGHT things about each job so that they will not form bad work habits. An error that is repeated a few times is well on its way to becoming a bad habit. You will have to learn the difference between oversupervising and not supervising enough. No one can do his best work with a supervisor constantly supervising. On the other hand, you cannot turn an entire job over to an inexperienced person and expect him to do it correctly without any help or supervision.

In training lower rated personnel emphasize the importance of learning and using correct

terminology. A command of the technical languages of your occupational field (rating) enables you to receive and convey information accurately and to exchange ideas with others. A persons who does not understand the precise meaning of terms used in connection with the work of his rating is definitely at a disadvantage when he tries to read official publications relating to his work. He is also at a great disadvantage when he takes the examinations for advancement. To train others in the correct use of technical terms, you will needed to be very careful in your own use of words. Use correct terminology and insist that personnel you are supervising use it too.

You will find the Record of Practical Factors, NavPers 1414/1, a useful guide in planning and carrying out training programs. From this record, you can tell which practical factors have been checked off and which ones have not yet been done. Use this information to plan a training program that will fit the needs of the personnel you are training.

On-the-job training is usually controlled through daily and weekly work assignments. When you are working on a tight schedule, you will generally want to assign each person to the part of the job that you know he can do best. In the long run, however, you will gain more by assigning personnel to a variety of jobs so that each person can acquire broad experience. By giving people a chance to do carefully supervised work in areas in which they are relatively inexperienced, you will increase the range of skills of each person and thus improve the flexibility of your working group.

Working With Others

As you advance to PO1 or CPO, you will find that many of your plans and decisions affect a large number of people, some of whom are not even in your own occupational field (rating). It becomes increasingly important, therefore, for you to understand the duties and the responsibilities of personnel in other ratings. Every Petty Officer in the Navy is a technical specialist in his own field. Learn as much as you can about the work of others, and plan your own work so that it will fit into the overall mission of the organization.

Keeping Up With New Developments

Practically everything in the Navy—policies, procedures, publications, equipment, systems—is subject to change and development. As a PO1 or CPO, you must keep yourself informed about changes and new developments that affect you or your work in any way.

Some changes will be called directly to your attention, but others will be harder to find. Try to develop a special kind of alertness for new information. When you hear about anything new in the Navy, find out whether there is any way in which it might affect the work of your rating. If so, find out more about it.

SOURCES OF INFORMATION

As a PO1 or CPO, you must have an extensive knowledge of the references to consult for accurate, authoritative, up-to-date information on all subjects related to the military and professional requirements for advancement.

Publications mentioned in this chapter are subject to change or revision from time to time—some at regular intervals, others as the need arises. When using any publication that is subject to revision, make sure that you have the latest edition. When using any publication that is kept current by means of changes, be sure you have a copy in which all official changes have been made.

The reading list at the beginning of this manual consists of USAFI courses that offer additional background material. The educational services officer will always have the most up-to-date information and training manuals applicable to your rating.

In addition to training manuals and publications, training films furnish a valuable source of supplementary information. Films that may be helpful are listed in the U.S. Navy Film Catalog, NavAir 10-1-777.

ADVANCEMENT OPPORTUNITIES FOR PETTY OFFICERS

Making Chief Petty Officer is not the end of the line as far as advancement is concerned. Proficiency pay, advancement to Senior (E-8) and Master (E-9) Chief, and advancement to Warrant Officer and Commissioned Officer are among the opportunities that are available to qualified petty officers. These special paths of advancement are open to personnel who have demonstrated outstanding professional ability, the highest order of leadership and military responsibility, and unquestionable moral integrity.

PROFICIENCY PAY

The Career Compensation Act of 1949, as amended, provides for the award of proficiency pay to designated military specialities. Proficiency pay is given in addition to regular pay and allowances and any special or incentive pay to which you are entitled. Certain enlisted personnel in pay grades E-4 through E-9 are eligible for proficiency pay. Proficiency pay is awarded in two categories: (1) Speciality pay—to designated ratings and NEC's, and (2) Superior performance pay—for superior performance of duty in certain specialities not covered by speciality pay. The eligibility requirements for proficiency pay are subject to change. In general, however, you must be recommended by your commanding officer, have a certain length of time on continuous active duty, and be career designated.

ADVANCEMENT TO SENIOR AND MASTER CHIEF

Chief Petty Officers may qualify for the advanced grades of Senior and Master Chief Petty Officer which are now provided in the enlisted pay structure. These advanced grades provide for substantial increases in pay, together with increased responsibilities and additional prestige. The requirements for advancement to Senior and Master Chief Petty Offices are subject to change but, in general, include a certain length of time in grade, a certain length of time in the naval service, a recommendation by the commanding officer, and a sufficiently high mark on the Navy-wide examination. The final selection for Senior and Master Chief Petty Officer is made by a regularly convened selection board.

Examination Subjects

Qualifications for advancement to Senior Chief Petty Officer and Master Chief Petty Officer have been developed and published in the Manual of Qualifications for Advancement, NavPers 18068 (Series). They officially establish minimum military and professional qualifications for Senior and Master Chief Petty Officers.

Bibliography for Advancement Study, NavTra 10052 (Series) contains a list of study references which may be used to study for both military and professional requirements.

The satisfactory completion of the correspondence course titled Navy Regulations, NavPers 10740-A4, is mandatory for advancement to E-8, and the course titled Military Justice in the Navy, NavPers 10993-A, is required of all personnel advancing to E-9.

ADVANCEMENT TO WARRANT AND COMMISSIONED OFFICER

The Warrant Officer program provides opportunity for advancement to warrant rank for E-6 and above enlisted personnel. E-6's, to be eligible, must have passed an E-7 rating exam prior to selection.

The LDO program provides a path of advancement from warrant officer to commissioned officer. LDO's are limited, as are warrants, in their duty, to the broad technical fields associated with their former rating.

If interested in becoming a warrant or commissioned officer, ask your educational services officer for the latest requirements that apply to your particular case.

CHAPTER 2

AVIATION SUPPLY

A Chief or First Class Aviation Machinist's Mate J, especially if in a supervisory billet, will find himself increasingly involved in the details of supporting the man on the job. One of these areas is in the field of aviation supply.

Aviation supply personnel are vital members of the aircraft maintenance team; and the ADJ, as well as personnel in the other aviation maintenance ratings, must work in close harmony with them if successful teamwork is to be achieved. The team must work so that a flow of parts is maintained from the manufacturer to the man on the job—quite possibly an ADJ doing repair work on the other side of the world. A correct concept of supply's relationship to the entire organization is essential in the supervision of aircraft maintenance functions.

ORGANIZATION AND FUNCTION OF NAVAL SUPPLY

The command exercising management control over the policies and procedures of the aviation supply organization is the Naval Supply Systems Command. The Commander, Naval Supply Systems Command is usually a rear Admiral who is appointed by the President with the advice and consent of the Senate. He works with the delegated authority of the Secretary of the Navy, and all policies and procedures of the aviation supply organization emanating from him have the full force and effect of SecNav orders.

To better understand the relationship of the Naval Supply Systems Command to the aviation supply system, it might be well to quickly review the development of the Navy supply system.

Prior to 1842 the commanding officers of ships and stations were responsible for the procurement of their own supplies. They were furnished funds for this purpose by the Navy Department and were required to account for all expenditures. In addition to creating an intolerable burden of paperwork on the Navy Department, this procedure had the effect of forcing prices upward, especially when two commanding officers were bidding for some scarce commodity.

In 1842 Congress approved the establishment of a Bureau of the Navy to take cognizance over all matters of naval supply. The primary responsibilities of this infant supply bureau were the procurement, maintenance of custody, and issuance of naval material. They are the primary responsibilities of the Naval Supply Systems Command today. Every function of the Naval Supply Systems Command is directly related to one or more of these responsibility areas.

In the early years of naval aviation when the Navy had few aircraft, the procurement of spare parts was much like the old system whereby commanding officers dealt with the sellers to fill the needs of each command. The pioneer naval aviation project directors had to deal directly with the manufacturers as parts were required.

By 1917 the Naval Aircraft Factory (NAF) in Philadelphia had come into existence and was assigned responsibility for the procuring of aircraft and spare parts. Other responsibilities assumed by NAF included the repair of aircraft, the manufacture of some spare parts, and eventually the manufacture of complete aircraft. There may still be a few aviators around today who earned their Navy wings in the old N3N, built by NAF.

In 1921 the Bureau of Aeronautics (BuAer) came into being and assumed the responsibility of procuring aircraft and aircraft engines. The responsibility for procuring spare parts and other aeronautical material remained with NAF, which until 1941 was the aviation supply center of the Navy.

The Aviation Supply Office (ASO) was established in 1941 under the technical control of BuAer and the management control of the Bureau of Supplies and Accounts. The function of ASO was the procurement, custody, and issuance of aeronautical spare parts and technical material. This is essentially the function of ASO today under the technical control of the Naval Air Systems Command. Management control of ASO is exercised by the Naval Supply Systems Command.

RESPONSIBILITIES OF THE NAVAL MATERIAL COMMAND

The Naval Aviation Maintenance Program is sponsored and directed by the Chief of Naval Operations (CNO). It is administered through the operating chain of command and is provided material and technical support by the Naval Material Command under the direction of the Chief of Naval Material (CNM). The Naval Material Command was established in 1966 with the cognizance over six systems commands. The cognizant system commands are listed below:

Naval Air Systems Command
Naval Electronic Systems Command
Naval Ship Systems Command
Naval Ordnance Systems Command
Naval Supply Systems Command
Naval Facilities Engineering Command

The Naval Supply Systems and Naval Air Systems Commands are the two systems commands of most interest to the AD personnel. Listed below are some of the important functions of the Naval Supply Systems Command and the relationship to the Naval Air Systems Command:

1. Supervises the procurement, receipt, custody, warehousing, and issuance of Navy supplies and materials, exclusive of ammunition, projectiles, mines, explosives, and medical supplies.

2. Supervises and directs the operation of the supply phases of the Navy supply system and administers the redistribution program of excess personal property within the Department of Defense and the sale of Navy surplus property.

3. Authorizes and supervises the transportation of Navy property.

4. Prepares budget estimates and administers funds for the supply distribution system.

5. Renders an annual report to the Congress of money value of supplies on hand at the various stations at the beginning of each fiscal year, the disposition thereof, purchase and expenditure of supplies for the year, and balance on hand.

6. Coordinates the compilation and arranges for the printing of the Catalogs of Navy Material.

Some additional functions of the Navy Supply Systems Command that are of interest to AD personnel are the general functions of ASO; these include the following:

1. Responsibility for overall determination of requirements, procurement, and distribution of standard aeronautical materials. (Certain materials excepted; such as complete aircraft and engines, complete electronic equipment, major photo equipment, nonstandard and experimental aerological equipment, and items of naval weapons ordnance equipment.)

2. Maintenance of a complete file of ASO and Naval Air Systems Command contracts, letters of intent, amendments, extensions, and change orders, and distribution of all (necessary copies of documents to Navy field) activities.

3. Stock control of aeronautical materials at all aviation supply facilities, including control of packing, preservation and distribution of material under ASO cognizance to, from, and between aviation supply facilities and major supply points.

4. Maintenance of complete records of material on order and followup procedure necessary to effect timely deliveries of all material under ASO cognizance.

5. Maintenance of up-to-date records of existing storage facilities at depots, major supply points, and operating stations for aeronautical materials, and control of influx of materials in aviation supply channels so as not to exceed existing storage facilities.

6. Determination and disposition of obsolete and excess aeronautical material under NavAirSysCom cognizance.

7. Preparation and distribution of the Navy Stock List of ASO, including interchangeability data.

8. Compilation and distribution of some allowance lists subject to approval by NavAir SysCom.

9. Compilation of lists of spare parts to be salvaged from surveyed aircraft.

10. Followup on delivery, stock recording, reallocating as necessary, and distributing change material promulgated by NavAir Sys Com.

11. Establish and maintenance of a statistical unit which assemblies, compiles, and analyzes usage data.

12. Maintenance of a representative at each aircraft manufacturer's plant who keeps ASO fully informed, as requested, as to all changes which affect spare parts under procurement.

13. Establishment of an inspection service which inspects aviation supply activities within established naval districts.

APPROPRIATIONS

At one time or another, almost everyone has had the frustrating experience of not being able to draw from supply some item needed immediately; the usual reason given being. "We do not have any money left." It takes only a short time to realize that the Navy does not operate with unlimited funds. This section and the following section, titled "Operating Budgets," are presented to further an understanding of the system whereby funds are made available at the user activity level for operating expenses.

The main money pool of the government is the General Fund of the Treasury. Funds come into the General Fund from such sources as income taxes, excise taxes, import-export taxes, etc. The only way for money to be expended from the General Fund is by congressional action, which has to be approved by the President. A bill passed by Congress which includes the expenditure of funds from the General Fund is called an appropriation.

An estimate of the amount of money required for the operation of the Defense Department during a given fiscal year is prepared by Department of Defense fiscal experts well in advance of the beginning of the fiscal year. The Congress studies the proposed budget in the light of world affairs, the current domestic economy, and such other considerations as they see fit, then acts upon it. Congress may increase the amount requested, decrease it, or pass it as is. After presidential action is completed, the money is made available to the Department of Defense to be spent during a specified year. This is known as an "annual" or "one-year" appropriation.

Congress and the President may also approve "no-year" appropriations for special projects such as large construction programs over an unspecified length of time.

Another form of appropriation is the "multiple-year" appropriation for projects which will be completed in a predictable length of time. An example of the use of this type of appropriation is the money appropriated to cover the expenses of the NROTC college programs for the next 4 years.

The appropriation by which the AD is most affected is the "current-year" appropriation. After the appropriation or expenditure authorization is received in the Department of Defense, it is prorated among the services as a percentage of their previously submitted budget estimates. The Navy's share is prorated among the various systems commands and bureaus in essentially the same manner; that is, as a percentage of their estimated requirements for the coming fiscal year. The money to be spent for naval aviation is made available to NavAirSysCom. Here, part of the money is allocated to ASO for the purchase of aircraft spare parts and related equipment in quantities which past usage data has indicated will probably be sufficient for the coming year. These spare parts are furnished to the operating activities at no cost, since their usage has been anticipated and the items paid for in advance. The account from which money was spent to buy these items is known as the Appropriation Purchase Account (APA). Material received in the user activities from this account is known as APA material.

Another part of NavAirSysCom funds is made available to the operating activities in the form of operating budgets.

OPERATING BUDGETS

Funds available within an appropriation account for commitments, obligations, and expenditures are administered through the issuance of operating budgets. An approved operating budget is an authorization granted for the purpose of incurring commitments, obligations, and expenditures to accomplish the mission of an activity. Therefore, an approved operating budget is a subdivision of an appropriation which provides the funding authority for an official to accomplish a specific function or mission.

Approved operating budgets concerning naval aviation are authorizations by NavAirSysCom to the user activities to spend a certain amount of money during a given length of time for specified purposes. User activities are shore commanders.

Operating funds for stations, rework activities, etc., concerned with the operation and maintenance of aircraft and related equipment are allotted to them by the NavAirSysCom as an

operating budget. Departments within these organizations normally submit their department budget to the station comptroller who reviews and combines the different department budgets into a recommended station budget. Senior AD's may be called upon to assist in furnishing a realistic estimate of division operating expenses and future needs which the department head may use in formulating the department budget.

Since there is a relatively long period between budget submission and the subsequent receipt of funds, the necessity of accurate estimates of future requirements and strict management of materials for which allotted funds are expended cannot be overemphasized.

Operating Targets

Funds to finance the operation of aircraft are allotted by the NavAirSysCom to the air type commanders. Operating funds for squadrons and units are apportioned to them by their cognizant air type commander as an operating target (OPTAR). An OPTAR is a planned estimate which the air type commander allocates for the financing of aircraft operating costs during a given period of time. OPTAR's are issued on a quarterly basis and unused funds from the previously issued OPTAR revert to the control of the type commander as each new OPTAR is authorized. Type commanders provide OPTAR's to squadrons, units, and ships under their operational control, whether or not the user activity is based ashore.

There are several different types of OPTAR's issued by air type commanders for aviation purposes. Two that are of interest to AD personnel are flight operations and aircraft maintenance funds. These are discussed in the following paragraphs.

Flight operation funds are used primarily for the purpose of financing actual flight operations; therefore, they have application at the Organizational level. These funds finance the following:

1. Aviation fuels and lubricants consumed in aircraft.
2. Liquid oxygen.
3. Aerial film for use in aircraft cameras.
4. Flight clothing and operational equipment authorized in NavAirSysCom Allowance List (NavAir 00-35QH-2).
5. Flight deck safety shoes.
6. Squadron administrative consumable office supplies.
7. Unit identification marks (shoulder patches) for initial issue to newly reported personnel.
8. Material and services required when located at an activity without Navy or Marine Corps Intermediate maintenance capability.

Aircraft maintenance funds are provided to Organizational and Intermediate maintenance activities to finance the cost of various supplies and materials consumed in the performance of aviation maintenance. These funds finance the following:

1. Repair parts, common hardware, lubricants, cleaning agents, cutting compounds, metals, and other materials incorporated into or expended in the performance of aviation maintenance of aircraft, engines, aeronautical components and subassemblies, and Navy maintenance of aviation maintenance support equipment.
2. Fuels and lubricants consumed by aircraft engines in the performance of complete section repairs.
3. Pre-expended, consumable maintenance material.
4. Replacement of expendable or consumable allowance list items with material accountability codes B and C. (Allowance list and material accountability codes are discussed later in this chapter.)

MATERIAL IDENTIFICATION

In addition to the task of supervising lower rated AD personnel in the performance of routine duties, senior AD's may be assigned maintenance supervisor duties. In some cases, these duties will encompass the task of assisting in the procurement of material and parts used by production personnel. One important area of material procurement is the correct identification of the material and parts required. Since at pay grade E-9, AD's compress with other maintenance ratings and become Master Chief Aircraft Maintenancemen, it is important that senior AD's be familiar with some of the methods of identifying material.

There may be times when a part or some technical material is needed and the stock number is unknown. At other times some material may be on hand and its identity not positively known. A knowledge of the various methods of identifying material other than by stock number will often help speed the completion of a maintenance task. Certain data may be available which do not identify an item but which may lead

to positive identification. The following sections discuss some methods of identifying material.

FEDERAL STOCK NUMBERING SYSTEM

The Defense Cataloging Standardization Act, passed by Congress in 1952, provided for a uniform system of identification, classification, and stock numbering throughout the Department of Defense. Prior to this time there were many stock numbering systems within the Department of Defense and within the Navy itself. It was possible for the same item to be stocked under different stock numbers as Navy general stores, Navy aviation stores, Air Force stores, Army quartermaster stores, and many others. There was no cross-reference system whereby an agency could determine if its excess material was the same as that which was in short supply in another agency.

The federal cataloging system eliminated this situation by placing all like items under a federal stock number bearing a common official government name. This system was made applicable to all agencies within the Department of Defense.

Under the federal cataloging system, federal stock numbers are required for all items that are subject to central inventory management within the Department of Defense. Each Navy item to be stocked under centralized inventory control is assigned a federal stock number which is used in all supply management functions. This federal stock is listed in supply publications in which the item is referenced.

The following paragraphs discuss the various parts of a coded FSN and frequent reference to figure 2-1 will assist in understanding the composition of coded FSN's.

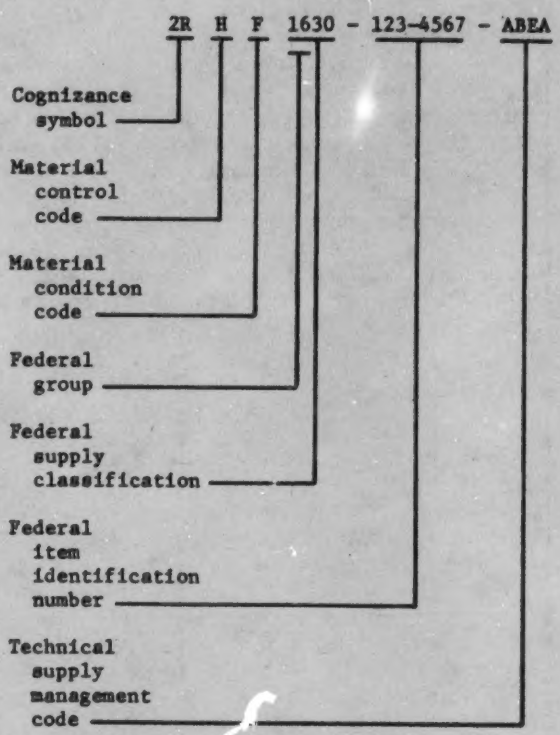


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Figure 2-1.—Breakdown of coded federal stock number.

A cognizance symbol consists of a 2-digit code prefixed to an FSN to identify and designate the systems command, office, agency, or Navy inventory manager that exercises management control over specific categories of material. Although the cognizance symbol officially consists of two digits, it will be observed that publications and requisitioning procedures frequently drop the first digit for APA material, thus 2R is referred to as R, etc.

Listed in table 2-1 are some of the more common cognizance symbols, together with the type material controlled and the name of the cognizant command or office.

The Federal Stock Numbering System was intended to create and improve standardization of items of military supply in servicewide use and reduce excess inventories which, for the most part, were caused by the lack of standardization. Also, the reduction of excess inventories eliminates substantial financial loss due to material obsolescence.

Federal Stock Number (FSN)

The FSN is an 11-digit number which furnishes positive identification of virtually all items of supply from purchase to final disposition. The 11 digits are uniformly arranged in groups of 4, 3, and 4 digits, with groups separated by hypens. The 11 digits are made up of a 4-digit federal supply class (FSC) and a 7-digit federal item identification number (FIIN). In addition to the 11-digit number, the Navy supply system utilizes certain code prefixes and suffixes to aid in the performance of various

Table 2-1.—Cognizance symbols.

Symbol	Cognizant activity	Material controlled
1E	Aviation Supply Office	Photographic material
2R	Aviation Supply Office	Aeronautical equipment
2V	Naval Air System Command	Aeronautical equipment (certain items only)
1N	Electronics Supply Office	Electronic equipment
20	Naval Training Devices Center	Training devices
1W	Fuel Supply Office	Fuels, lubes, and gases
1I	Naval Supply Depot, Philadelphia	Forms
0I	Naval Supply Depot, Philadelphia	Publications

management functions. These codes are of significance only within the Navy and are not used during interservice transactions. When the prefixes and suffixes are used, the FSN is known as a coded FSN.

Figure 2-1 describes the format of a coded FSN, including applicable management codes for an item of supply under the cognizance of ASO.

Material control codes divide inventories into segments reflecting similar demand, repairability, or other characteristics. For example, some material control codes reflect either fast or slow moving demand characteristics, while others denote whether the item is to be repaired by Intermediate or Depot level maintenance activities.

Material conditions codes classify material in terms of readiness for issue and use, or to identify action underway to change the status of material. For example, one material condition code is used to indicate that a particular item is serviceable and ready for issue. If, after issue from the supply system and through use this item becomes unserviceable, its material condition code would be changed to reflect the requirement for rework, repair, etc. Naturally, upon completion of rework or repair the material condition code would be changed to show that the item is serviceable and ready for issue. Therefore, this code changes from time to time on a particular item depending on the condition of the material.

The federal supply classification (FSC) class is the first four digits of the FSN and is used to group related commodities together. Each item of supply is classified in one, and only one, 4-digit FSC. The first two digits denote the group or major division of commodities, and the last two digits denote the class or subdivision of commodities within a group. Aircraft components and accessories are in group 16; therefore, in the FSC 1630, the 16 denotes an aircraft component or accessory and the 30 indicates a particular class within this group, which is aircraft wheel and brake systems. Other classes in group 16 are indicated as 1610—propellers, 1620—landing gear components, etc.

The federal item identification number (FIIN) consists of the last seven digits of the FSN. It serves to differentiate each individual item of supply from all other items of supply. Therefore, each individual item of supply such as brake, F-4B; brake, P-3A; etc., is assigned a separate FIIN. The FIIN in no way determines the position or sequence of the item in relation to other items.

The technical supply management code (TSMC) is a four-character code suffixing the FSN. As previously discussed, the FSC classifies material by what it is. The TSMC groups material by associating supporting spare parts with their end assemblies.

NOTE: A recent change has replaced the four-character TSMC with a two-letter special material identification code (SMIC). However, like many areas where changes are made, a certain time element is involved; therefore, the TSMC will still be used for some time on many coded FSN's. A SMIC is a management code added as a suffix to an FSN to indicate a primary weapon support item, specialized materials or general/common material. ASO has published a conversion guide which cross references the SMIC with the TSMC.

Many variations of coded stock numbers will be encountered in maintenance work. These variations indicate material management responsibilities for the item; flag certain items as recoverable, consumable, high value, etc.; and identify the condition of the material if it is not ready for issue.

Because the variety of codes is so extensive and the trend to single service management of items has caused so many changes in recent years, a list of codes that might be prefixed or suffixed to a stock number would not be appropriate for this course. The primary things to keep in mind are that the basic stock number, consisting of three groups of numerals, identifies the item from a technical point of view and that the other codes identify material management characteristics.

STANDARDIZATION OF ITEM NOMENCLATURE

As part of the federal cataloging system, each items of supply is assigned an official government name. Maintenance personnel frequently refer to material by trade name or terminology other than the official government name. Alphabetical indexes in the various stock catalogs and other publications are sequenced by official name. To effectively utilize these publications, it is necessary to become acquainted with the proper nomenclature.

The assignment of names to stock items is practically as important as the assignment of FSN's. When items are inducted into the supply system, official government nomenclature must be assigned. Often this item name plus additional descriptive data will differ from names of items previously used. If difficulty is experienced in locating a familiar item in the catalog, it is quite possible that the name has been changed to conform to a more general usage. A few examples will show the importance of correct item nomenclature. It will be found that a "swab" is a small stick with a tiny wad of cotton on one end, and is used by the Medical Department. In order to clean the decks it will be necessary to think of another name for "swab." "Mops" will be found listed in the catalog, together with the correct FSN. Other samples are as follows: "Ceilometer" becomes "Projector, Cloud Height"; "Zipper" has become "Fastener, Slide Interlocking," etc.

NAVAL MATERIAL CATALOGS

Federal and naval material catalogs provide information necessary to identify and procure items of material for operation and maintenance of activities afloat and ashore. The catalog most commonly used by aviation personnel is the Federal Supply Catalog Navy Management Data List.

The Navy Management Data List (NMDL) consists of two separate sections. One section, the Fleet Ballistic Missile Weapons System Supplement, has application only to submarine forces and therefore is of little or no use to aviation maintenance personnel.

The other section, titled the Management Data List, includes basic management data necessary for preparing material requisitions. Also, it is the instrument for publishing data relative to stock number changes, unit of issue, unit price, shelf life of material, number of items contained in a package, and associated information.

The NMDL is designed to disseminate management type information as it relates to an FSN. It is not designed to act as a comprehensive catalog of material in the supply system, identify an item to an FSN, or serve as a shopping guide. Therefore, in order to get the necessary FSN or other needed information for making effective use of the NMDL, additional publications must

be used in conjunction with the NMDL. These include the Deleted and Superseded FIIN List, the Consolidated Repairable Item List, and the Federal Supply Catalog Navy Master Cross Reference List.

The Deleted and Superseded FIIN List provides historical data of stock number deletions and supersessions. It should be remembered that the FIIN taken from this list is referred back to the NMDL for the requisitioning data.

The Consolidated Repairable Item List contains a listing of Navy managed mandatory turn-in repairable items. It is prepared to assist in identifying Navy managed mandatory turn-in repairable items and pertinent movement priority designators. Some repairable items under the cognizance of ASO and the NavAirSysCom are not included in this publication. These are listed in the ASO Master Repair List.

The Federal Supply Catalog Navy Master Cross Reference List provides the means of identifying an item from a reference number (part number, drawing number, etc.) to an FSN. The FSN found in this publication should be referenced back to the NMDL for all pertinent information required in requisitioning material.

IDENTIFICATION SOURCE DATA

As previously stated, positive identification of an item of supply has been accomplished when it is identified to its applicable FSN. For the most part, the FSN is not marked on material; however, most material has some type of data affixed to it that can be used for identification purposes. Certain data which do not identify an item but which aid in obtaining positive identification are discussed in the following paragraphs.

Manufacturer's Part Number

Normally, the manufacturers of parts stamp, etch, paint, or otherwise affix a part and manufacturer's code (vendor code) numbers on each item manufactured. The use of these numbers, part and code, and the knowledge of the part's application (that is, on what equipment it is used) normally lead to positive identification of the part's nomenclature and FSN. Due to the possible duplication of part numbers by manufacturers the manufacturer's code (VENDOR) will be used with the part number. The part number and vendor code can usually be found on the part, and/or IPB for the item needed. The vendor's code is a five-digit code. If a vendor code cannot be firmly established in the master file, a code of 99999 will be inserted. As the vendor codes are established, the file will be updated and subsequent issues of the index will reflect the assigned vendor code. After ascertaining the correct part and code number the FSN may be obtained by reference to the appropriate Federal and Naval Material Catalogs.

Drawing Number

A drawing number consists of letters, numbers, or a combination of both which are assigned to a particular drawing for identification purposes. The activity controlling the drawing (normally the manufacturer) assigns the number in conformance with their drawing number system. One drawing may apply to several items; thus other distinguishing data may be necessary to identify the item on the drawing.

Drawing numbers may be used to identify the microfilm available in some technical libraries. Some large assemblies are illustrated in the appropriate Illustrated Parts Breakdown but are not broken down sufficiently to show identifying data for their component parts. By obtaining the drawing number of the larger item and cross-referencing it to the applicable microfilm, sufficient identifying information for the component part may be obtained.

Nameplates

Some aeronautical materials have nameplates attached which provide such information as the manufacturer's name or code, make or model number, serial number, size, voltage, phase, etc. Identification data taken from the nameplate of the old part can be very helpful in identifying and procuring a replacement. Nameplate data is particularly useful when requesting nonstandard material which is not subject to the federal cataloging system.

Markings and Measurements

Special coded markings, other than part numbers, and measurements often aid in the identification of some materials. For instance, compressed gas cylinders are color coded to identify the contents of the cylinders. Sheet metal is stamped with a significant identifying symbol which is repeated at intervals throughout the

length of the sheet. This symbol includes the composition, temper, thickness, etc.

Flexible rubber hose is marked with a symbol which is repeated at intervals throughout the length of the hose. Bare wire is separated according to diameter. Tubing has two types of measurements—outside diameter, given in inches; and thickness of the wall, given in thousandths of an inch. Female fittings such as crosses, tees, and couplings are measured across the inside diameter of the threaded opening. The male fittings are measured across the outside diameter of the male threads.

Source Codes

Item Sources Codes are symbols which indicate to a consumer a source of supply for an item required to maintain or repair aeronautical articles. Specifically, these codes indicate whether the item is to be requisitioned from the supply system; to be manufactured; to be obtained from salvage; not to be replaced since the next higher assembly is to be installed; or, due to failure, is in need of complete overhaul or retirement of the assembly or equipment from service.

Source codes are assigned to material at the time of provisioning. Known or anticipated usage is the primary factor in the assignment of source codes. The ability to manufacture an item within a naval activity is considered to be of secondary importance. In other words, items are normally source coded for purchase and stocking in the Navy supply system if usage is known or anticipated. Source codes for individual items may be revised as experience and usage develop.

Source codes are published as a column of the numerical index of the Illustrated Parts Breakdown, and in other publications as directed by the NavAirSysCom.

Source codes are provided in six series—P, M, A, N, X, and U.

Source code P series applies to items of supply system stock which are purchased in view of known or anticipated usage.

Source code M series applies to items which are not purchased but are capable of being manufactured at Navy fleet or overhaul activities. These items are normally manufactured upon demand and are not stock numbered.

Source code A series applies to assemblies which are not purchased.

Source code N series applies to items (nuts, bolts, screws, etc.) which do not meet established criteria for stocking and which are readily available from commercial sources. These items are purchased on demand.

Source code X series applies to items not procured and not practical for storage, maintenance, or manufacture.

Source code U applies to items which are not of supply or maintenance stocking significance.

Within each of the source code series, there are one or more subcodes identified by a letter or number appended to the basic code number. These subcodes provide detailed information concerning the procurement or manufacture of various parts within the scope of the particular code series. The applicable Illustrated Parts Breakdown provides ready reference for each of the codes and subcodes as required.

The preceding sections have emphasized some of the many things that may be used to identify or aid in procurement or use of material. The senior AD who is familiar with the methods of identifying material is an asset to a maintenance organization, especially in performing maintenance supervisory duties.

AERONAUTICAL ALLOWANCE LISTS

This title is inclusive of publications identified as Allowance Lists (except advanced base lists), Initial Outfitting Lists, and Tables of Basic Allowances.

Naval Air Systems Command Allowance Lists, Initial Outfitting Lists, and Tables of Basic Allowances are prepared by the NavAirSysCom or the Aviation Supply Office. In nearly all instances ASO has the responsibility for preparation, but in all cases these lists are published by the direction of and approved by the NavAirSysCom. These lists contain the following:

1. The equipment and material (both consumable and nonconsumable) necessary to outfit and maintain units of the aeronautical organization in a condition of material readiness.

2. Substantially all items used with sufficient frequency to justify their issuance to all activities maintaining aircraft or equipment for which the lists are designed.

3. Information concerning stock number, nomenclature, interchangeability, and supersedures.

4. A set of detailed instructions for the application and utilization of the publication.

5. A table of logistic data showing the total weight and cube of all material contained in the list.

In the final analysis, the equipment and spare parts listed in these publications are made available to aircraft operating and maintenance activities in accordance with assigned operational maintenance and logistics responsibilities through appropriate application of allowance lists and outfitting actions. The Aviation Supply Office has the responsibility for continually reviewing and updating allowance lists.

INITIAL OUTFITTING LISTS

Initial Outfitting Lists are publications which indicate the range and quantities of maintenance spare parts considered necessary to support various aeronautical end items. These lists contain repair parts, such as airframe parts, electronic parts, engine parts, and general aeronautical equipment. The material covered by Initial Outfitting Lists is normally retained in supply department stocks until required for issue. This allowance of material is provided to ships or activities and is firm only at the time of initial outfitting. Increases and decreases in both range and/or quantities of material are based upon usage data of each activity concerned. Each series lists is designed to support an aircraft, electronic equipment, or some other aeronautical article.

ALLOWANCE LISTS

These are publications which indicate the range and quantities of equipment and material considered necessary for maintenance support of assigned and/or supported aircraft. Generally, these items are inuse items required for daily or continual use, such as aircraft jacks, air compressors, and avionics test equipment.

Publications listing equipment and material required by activities for performance of assigned mission are known as Tables of Basic Allowance. They contain both shop equipment and common supporting spare parts. They cover allowances of tools and equipment required for use by such activities as Fleet Marine Force squadrons and target pilotless aircraft activities.

A complete listing of Aeronautical Allowance Lists, Initial Outfitting Lists, and Tables of Basic Allowance, with NavAirSysCom publication numbers and their effective dates, is contained in NavSup Publication 2002, Section VIII, Part C.

IDENTIFICATION AND TYPES OF ALLOWANCE LISTS

Allowance Lists and Initial Outfitting Lists are identified by the NavAirSysCom publication number 00-35Q (Series), while Tables of Basic Allowance are identified by the NavAirSysCom publication number 00-35T (Series). The following paragraphs discuss some of the various sections of allowance lists.

Section A, Standard Aeronautical Material and Naval Stock Account Material

Section A covers general material such as nuts, bolts, tubing, hose, paint, and other items common to the operation of all aircraft models. Both equipage and consumable supplies are shown in the Section A.

Section B, Aircraft Maintenance Parts

Section B contains airframe, engine, and accessories maintenance parts peculiar to each type of aircraft. A separate section B is issued for each model of aircraft.

Section C, Office Furniture and Laborsaving Devices

Section C lists the items and quantities of office furniture and laborsaving devices for the administrative support of deployable fleet air activities only.

Section G, General Support Equipment For All Types, Classes, and Models of Aircraft

Section G (Series) lists the quantities of handtools, handling and servicing equipment, and material which are made available for maintenance support of aircraft as may be assigned or supported.

Section H, Flight Operational Material

Section H is applicable to air task group commanders and all Navy and Marine squadrons operating aircraft or having aircraft assigned. It contains items and quantities of flight operational material considered necessary to

maintain the concerned activities in a continual condition of operational readiness.

Section K, Naval Aeronautical Publications and Forms

Section K outlines the general types and classes of aeronautical technical and training publications and forms which are provided as a commissioning allowance for various Navy and Marine Corps aviation activities. It lists those publications and forms which are issued by the Deputy Chief of Naval Operations (Air) and by the Naval Air Systems Command, but does not include publications provided to aviation activities by other Navy Department systems commands and bureaus, by fleet commands, or by non-Navy offices.

Section R, Aeronautical Electronics Material

Section R comprises Allowance Lists and Initial Outfitting Lists of electronic equipment and material required for the test and maintenance of aeronautical electronic equipments within the Naval Establishment.

Section Z, Special Equipment and Spare Parts

Section Z includes mobile electric powerplant spare parts and equipment and spare parts support for aircraft support equipment.

The foregoing section list breakdown includes only those sections of professional interest to the AD. The complete list includes allowance lists for arresting gear and catapults, photographic, aerological, etc.

ACCOUNTABILITY CODES

The accountability codes used in allowance lists and most Illustrated Parts Breakdowns are known as Material Accountability Recoverability Codes (MARC). MARC's are assigned only to aeronautical provisioned items to reflect the accountability, recoverability, and repair policy determined for an item of equipment or material required for the maintenance, repair, or rework of an end item. MARC is a system whereby a letter of the alphabet is used as a guidepost by personnel working with aviation material. This system helps personnel to determine the proper method of the following:

1. Requisitioning material with regard to inventory control and fiscal accounting procedures.
2. Accounting for material while in use.
3. Turn-in or disposition of material.
4. Repair or overhaul.

The following list defines the various material accountability codes.

B—Exchange Consumables

Code B is applied to items which are consumable or expendable but normally require item-for-item exchange for issue after the initial outfitting. Such items may contain precious metals, may be highly pilferable, or may be high cost items.

C—Consumables

Code C is applied to all other consumable or expendable items which do not require item-for-item exchange for replacement.

D—Equipage, Support Type

Code D is applied to end items of support equipment which are economical and practical to repair on a scheduled basis through a major rework activity. Code D items are maintained on a custodial signature basis and must be surveyed when lost or missing or when beyond econmical repair. After initial outfitting, Code D items require item-for-item exchange for replacement. Every effort should be made to repair Code D items locally or through fleet support activities prior to turning in the item to the supply system as non-RFI material.

E—Equipage, Locally Repairable, Support Type

Code E is applied to end items of support equipment which are to be repaired locally by the using or fleet support activity within their assigned maintenance responsibility. Code E items are maintained on a custodial signature basis when in use, require item-for-item exchange for replacement, and require surveying when lost or missing. The cognizant NavAirSysComRep may authorize repair of E items through customer service from a major rework activity in order to meet operational commitments.

R—Equipage

Code R is applied to repairable (except end items of support equipment) items which are economical and practical to repair on a programmed basis through a major rework activity. Code R items are repaired by local activities when the extent of the required repair falls within the maintenance capability of the activity. After initial outfitting, these items are issued only on an exchange basis or when necessary to replace an item expended by approved survey.

L—Equipage, Locally Repairable

Code L is assigned to repairable items (except end items of support equipment) which can be repaired by deployable squadrons within their assigned maintenance responsibility upon consideration of the following factors:

1. Manhours and skills required to perform the repair.
2. Total cost of providing necessary support equipment to perform the repair.
3. Total cost of providing necessary repair parts to perform the repair.

Items coded L are scrapped when economical repair is beyond local activity capabilities. After initial outfitting, issues of Code L items are made only when exchange procedures provide for turn-in of the replaced items or when necessary to replace an item expended by approved survey.

DEVIATIONS FROM ALLOWANCE LIST REQUIREMENTS

It is the policy of the NavAirSysCom to make available to each Navy activity the authorized equipment and repair parts necessary to insure operational readiness. Allowance list requirements are not mandatory and deviations are approved as pointed out in the following paragraphs.

Type, Force, and major operating commanders, or their subordinate logistics commanders, may authorize deviations from allowance list requirements. This includes one-time in-excess issue of equipment for a requirement not considered generally applicable to other activities of the same type, or for independent operations of detached activities.

Organizational and Intermediate maintenance activities often have requirements for equipment which does not appear on existing allowance lists. In some cases the equipment is requested because it is considered superior to existing equipment or it may be the result of an entirely new requirement; that is, for rework of a component or to perform repairs or services for which no previous capability existed.

In order to assure that each request for deviation is properly reviewed and evaluated for validity and possible application to other maintenance activities, the originating activity should submit an official request to the Naval Air Systems Command Headquarters, via the chain of command (including the cognizant NavAirSysComRep). The following general procedures are followed in approval or rejection for a new piece of support equipment where no previous capability or need existed.

The request, together with complete justification, should be forwarded via the chain of command to the NavAirSysComHq. The request should not be made through supply system channels. The type commander normally identifies, on the forwarding endorsement, the Intermediate maintenance activity which will perform the equipment evaluation if different from the requesting activity.

The NavAirSysComRep normally investigates the request and indicates on the following endorsement the availability of the requested equipment from existing resources. Upon review and approval, the NavAirSysComHq provides the activity concerned with the equipment. This equipment is considered a prototype and is for evaluation. No additional equipment is normally procured until the validity of the need can be determined. During the evaluation, the type commander and cognizant NavAirSysComRep performs monitoring actions and provides additional assistance as required.

The completed documentation of the evaluation is forwarded via the chain of command to the NavAirSysComHq. In the forwarding endorsement, the type commander normally suggests a criteria for allocation of equipment to other activities. Upon review of the evaluation report, the NavAirSysComHq notifies all concerned of the action taken. In case of approval, this includes ASO so appropriate action may be taken to insure updating allowance lists.

AIRCRAFT MAINTENANCE MATERIAL READINESS LIST (AMMRL) PROGRAM

This program has provided for the development of data and documentation needed to determine and establish firm support equipment

requirements and inventory control of aircraft maintenance support equipment. It provides for the construction of an Individual Material Readiness List (IMRL) for each aircraft maintenance activity, by name, prescribing items and quantities of aircraft maintenance material required for material readiness of that specific activity to which the list applies. This program also provides for the construction of material readiness lists to indicate the total quantities of each item authorized within stations, logistic areas, and major operating command areas.

Within the AMMRL program there are several material readiness lists; however, only two are discussed here.

The Application Data Material Readiness List (ADMRL) is used to specify the requirements for each item of aircraft maintenance support equipment against each level of maintenance and selected ranges of each aircraft, engine, propeller, and system for which each item is needed. Through the use of electronic data processing machines this data is used to develop Individual Material Readiness Lists.

The IMRL specifies items and quantities of aircraft maintenance support equipment required for material readiness of the aircraft maintenance activity to which the list applies. As previously stated, this list applies to an activity by name. The NavAirSysComRep is responsible for the preparation of the IMRL for each activity in his cognizant area. It is prepared by extracting from the AMMRL those applicable portions which pertain to the specific aircraft and maintenance material assignements of the activity for which the list is developed.

Maintenance/Material Control personnel maintain an updated IRML to support current and anticipated changes in aircraft maintenance support equipment requirements. Because the IMRL is continually reviewed and updated and approved by the cognizant command, it is the firm mandatory material readiness list of the activity to which the list applies.

SUPPLY ACTIVITY

The mission of the supply activity is to support the operational and maintenance efforts of the activity/ship. Stocks of aviation oriented material carried are tailored and replenished to this end. Positioning, replenishment, and control of stocks of material in maintenance areas are carried out as a result of joint decisions by the Supply and Maintenance Officers concerned. They determine the range, depth, and related procedures. The Naval Aviation Maintenance Program (NAMP) requires that the cost of material used in maintenance be determined and accumulated in such manner and detail that weapons system costing can be measured. Usage is finely defined as to stock number, within component, within system, within equipment/weapon/aircraft, in a particular squadron, located in a specific operational area, at a definite point in time. These data are used as an inventory management tool to determine geographic and strategic distribution of stocks of material. In addition, the data will be invaluable in establishing the material portions of work standards in maintenance.

SUPPLY SUPPORT CENTER (SSC) DIVISION

Maintenance organizations have one point of contact with the supporting supply activity. This single contact point is the Supply Support Center (SSC), which responds to all material requirements of the maintenance organizations. The SSC is an internal organization of the local supply department at the division level and is responsible to the supply officer. It is made up of two sections—the Supply Response Section (SRS) and the Component Control Section (CCS). In addition to these two sections, there is the preexpended bin element which may be organized as a section under the SSC supervisor or as a unit under SRS or CCS.

Supply support is available consistent with the operating hours of the maintenance activities supported. If maintenance is being performed 24 hours a day, then supply support is available 24 hours a day.

The supply support center maintains rotatable pool material which consists of repairable ready-for-issue items reserved primarily to satisfy the requirements of Organizational level maintenance. Items maintained in the pool are capable of being repaired by the local Intermediate maintenance activity, have application relationship to weapon systems supported by local Intermediate maintenance activities, and have an average Organizational maintenance level removal rate of at least one per month. Defective components are turned in to Intermediate level maintenance for repair. The defective components repaired to an RFI condition are then returned to the rotatable pool to replace the components previously issued.

Generally, items included in a rotatable pool are repairable items of supply which are under the issue control of the local supply officer. However, instances may occur when it is desirable to position some items or assemblies (such as a pre-soaked carburetor, built-up wheel assembly, built-up prop, etc.) in the pool for use by Organizational and Intermediate maintenance activities. Pre-positioning of items of this nature is acceptable as long as they aid in decreasing NOR time.

The local supply officer and aircraft maintenance officers concerned determine the range and quantity of each item required in the rotatable pool. Two elements used in this determination are the local repair cycle time and the local removal rate. The local repair cycle time is the average total elapsed time between removal of a component and the complete local repair of the item into an RFI condition. The local removal rate is the average number of defective components removed over a 3-month period, for which replacement RFI components were required.

After the components and the quantity of each that will be included in the pool have been determined, the supply officer publishes an official list of pool items. This listing provides a ready reference for the components carried in the pool. RFI rotatable pool items are withdrawn from the pool by the local supply officer only under the following conditions:

1. When actual usage indicates the item/quantity can no longer be justified as a reservation, and the aircraft maintenance officer concurs.
2. When requested by the aircraft maintenance officer.
3. Only as a last resort to satisfy non-local system requirements.

In order for the rotatable pool to fully serve its intended purpose there must be complete cooperation between the maintenance and supply organizations. Organizational maintenance activities must expedite return of defective components to supply so that these components can be delivered to the Intermediate activity for repair. The Intermediate activity must complete repairs in an expeditious manner so that the repaired components can be returned to supply to be placed in the rotatable pool. Then, the supply organization is able to offer maximum support in the form of RFI components to insure maximum aircraft readiness.

Supply Response Section (SRS)

The Supply Response Section (SRS) is responsible for preparing all necessary requisitions (DD Form 1348) and related documents required to obtain material for local maintenance use in direct support of weapon system maintenance. The maintenance organization verbally notifies the supply organization of the need of such material. When material is available locally, the time frame for processing and delivery is as follows:

Priority	Process/Delivery Time
1-3	1 hour NORS/NFE
4-8	2 hours
9-20	24 hours

The SRS is responsible for physical delivery of RFI material to maintenance organizations, and the pickup of defective components from the Organizational maintenance activity and subsequent delivery to the Intermediate maintenance activity. Actual maintenance personnel are not involved in the physical movement of material between organizations.

This section also performs technical research in regard to completion of requisition documents as well as determining the status of oustanding requisitions and relaying this status to the customer upon request.

The SRS accomplishes these functions through four units—the requisition control unit, the technical research unit, the stock locator unit, and the material delivery unit.

Component Control Section (CCS)

The CCS is responsible for the following functions:

1. Physically maintaining components in the rotatable pool.
2. Maintaining rotatable pool supplemental records.
3. Maintaining a suspense file for all components issued to customers on an exchange basis.
4. Maintaining a suspense file for all components in AIMD.
5. Processing all components received from AIMD.

The CCS accomplishes these functions through three units—the document control unit, the rotatable pool unit, and the supply screening unit.

Preexpended Bins Section

This section is responsible for establishing and maintaining stocks, in maintenance areas, of common repair parts that are considered to be high usage, low in cost, expended from supply department stock records, and expended from financial records.

MATERIAL CONTROL WORK CENTER

The material control work center in a maintenance activity performs a staff function, and as such provides support and services to the production divisions. It exists for the primary purpose of insuring that maintenance requirements for parts and materials are made known to the supply organization in a timely manner in order to prevent work stoppages and grounding aircraft. Material control insures that parts and materials made available to maintenance are systematically utilized and not allowed to accumulate or to become depleted. It serves as the single point of contact within the maintenance organization for the conduct of business with the supply organization.

The material control work center provides material support to their cognizant organization by accomplishing the following general functions:

1. Pass all requirements for material required for direct support of weapon system maintenance to the SSC. A material control register is maintained for these items.
2. Prepare documents for material required for indirect support of weapon system maintenance. Examples of materials for which documents are to be prepared are aviation fuels and lube oils, rags, and flight jackets. A separate requisition record log is maintained for these items.
3. Maintain liaison with the supporting SSC on maintenance material to insure that material needs of the organization are satisfied.
4. Establish delivery points for all material and insure that material received is expeditiously routed to the applicable work center.
5. Furnish technical advice and information to the supply activity on the identity and quantity of supplies, spare parts, and materials required for maintenance actions.
6. Establish procedures to insure the periodic inventory of tools and the adequate accountability of material and equipment on custody to the cognizant organization.
7. Initiate surveys in the event of loss, damage, or destruction of accountable material.
8. Keep the maintenance control work center advised of the overall supply situation as it affects the activity.
9. Perform cost and allotment record accounting, charting, and budgeting of cost applicable to the cognizant organization.
10. Monitor the operation of toolrooms and maintain an updated IMRL.
11. Maintain inventory control of authorized allowances of material.

The material control work center is responsible for the coordination of material ordering, receipt, and delivery. This is done in such a manner as to insure that the correct material is ordered and that it reaches the work center within the specified time frame.

The foregoing functions of the material control work center apply to both Organizational and Intermediate level activities. Some of the functions which are applicable to one level only are listed in the following paragraphs.

INTERMEDIATE LEVEL

An Administrative Screening Unit has been established in the material control work center of Intermediate maintenance activities. This screening unit does the following:

1. Positively identifies material and determines if it is within the repair capability of the AIMD.
2. Insures that all required documentation is affixed to the component (that is, logs, records, MAF, etc.).
3. Notifies maintenance control of the receipt of defective components for scheduling into the AIMD.
4. Transfers the defective components to the appropriate work center when directed by maintenance control.

All components received in the AIMD material control receive screening to determine if the item is within the check, test, or repair capability of the AIMD. As a result of this screening, components requiring maintenance within the AIMD capability are reported to maintenance control as ready for induction. Items beyond AIMD capabilities are returned to the Supply Support Center with appropriate recommendations for disposition. When work on components

in the AIMD has been completed, the components, together with required records, are returned to material control for appropriate routing back into the supply organization.

ORGANIZATIONAL LEVEL

In addition to the general functions, the material control work center in Organizational level activities is responsible for the following:

1. Verification of NORS (Not Operationally Ready Supply) requisitions and maintenance of current NORS status records.
2. Inventory of aircraft upon receipt and transfer and maintenance of inventory records.

When removed components are generated as a result of the maintenance effort, material control insures that the SSC is notified to make a pickup. These components must be accompanied by record cards and logs, when applicable, plus the number two, three, and four copy of the Maintenance Action Form.

MATERIAL CONTROL REGISTER

The Material Control Register is used by Intermediate and Organizational level material control work centers to record all material requested from the Supply Support Center in direct support of weapon system maintenance. Space is provided to record essential information considered necessary to monitor operating target (OPTAR) funds. This information includes part number, priority, quantity, price, date and time ordered, and date and time received. Maintenance control uses the time ordered and time received to help determine Not Operationally Ready Supply (NORS) time used in fulfilling readiness reporting requirements.

MATERIAL REQUISITIONING

The Military Standard Requisitioning and Issue Procedure (MILSTRIP) and Uniform Material Movement and Issue Priority System were developed by Department of Defense to provide a common supply language and more effective supply system operations within the military establishment. This system standardizes forms, formats, codes, procedures, and the priority system.

MILSTRIP employs two forms for the requisitioning and issuing of material. The Single Line Item Requisition Document (Form DD1348) is the basic request document submitted to the applicable supply echelon for material requirements. The issue document is the Single Line Item Release/Receipt document (Form DD 1348-1). Form DD 1348-1 is also used to return RFI material to the supply system. As previously stated, these forms will be prepared by the Supply Response Section of supply for all material requested in direct support of weapon system maintenance and by the material control work center for material requested in indirect support of weapon system maintenance.

Under the MILSTRIP priority system the decision to be made in assigning priorities is the urgency-of-need. This combined with the unit's military importance when applied to the priority number chart (table 2-2), indicates the proper priority number.

Table 2-2.—Priority number chart.

Force/activity designator	Urgency-of-need-designator		
	A	B	C
	Priorities		
I	01	04	11
II	02	05	12
III	03	06	13
IV	07	09	14
V	08	10	15

The force/activity designators represent categories of activities in descending order of military importance, ranging from the combat forces under I to the miscellaneous activities under V. Every activity is assigned one of the five force/activity designators according to their military importance. These designators are as follows:

I - COMBAT—The highest order of military importance. This designator is not used in peacetime unless approved by the President or the Joint Chiefs of Staff.

II - POSITIONED—U.S. Forces positioned and maintained in a state of readiness for immediate combat or direct combat support.

III - READY—U. S. Forces maintained in a State of readiness to deploy for combat.

IV - RESERVE AND SUPPORT—U. S. active and selected reserve forces planned for employment in support of approved joint war plans. This category includes training units and units in training for scheduled deployment.

V - OTHERS—All units not otherwise assigned.

Force/activity designators (F/AD's) are assigned by the Joint Chiefs of Staff or by each Department of Defense component service. The Chief of Naval Operations has authority to delegate assignment of F/AD's (other than I) to Commanders-in-Chief of Fleets. Each activity is advised by the appropriate military commander of the assigned designator which governs the procurement of material for that activity.

The letters across the top of table 2-2 represent different degrees of urgency, in descending order of need, from an extremely serious need under A to routine stock replenishment under C. The urgency designator is selected by the requesting activity. Definitions of the Urgency-of-Need Designators (UND) for aviation units (including IMA's) are as illustrated in table 2-3.

Table 2-3.—Urgency-of-need designators (definitions).

UND	Definition
A	(1) Emergency requirements for primary weapons, equipment, and material for immediate use without which the aircraft concerned is unable to perform assigned operational missions (NORS). (See Note 1.)
	(2) Items required for immediate end use in direct support of equipment essential to the operation of aircraft (e.g., ground support, firefighting, etc.) without which the aviation unit is unable to perform its mission. (See Note 1.)
	(3) Items required, to eliminate an existing work stoppage at an Intermediate maintenance activity modifying or maintaining primary aircraft or aircraft equipment.
	(4) Items required to eliminate an existing work stoppage at an Intermediate maintenance activity performing repair and maintenance on unserviceable high value/critical item repairables.
	(5) Items required to effect emergency replacement or repair of essential physical facilities of an Intermediate maintenance activity, without which the activity cannot carry out its mission. (See Note 1.)
	(6) UND "A" may be used for Not Fully Equipped (NFE) requirement only when the item(s) are needed to return mission essential subsystems and equipments to operational status.
B	(1) Item(s) required for immediate end use, the lack of which is impairing the operational capability of the aircraft or organizational unit concerned.
	(2) Item(s) required for immediate end use to effect repairs to aircraft and aircraft support equipment, without which the operational capability of the aircraft is impaired or effectiveness in accomplishing assigned mission is reduced.
	(3) Item(s) required for the replacement of mission essential items on allowance/load lists where the last item has been issued out of bin to end use or the quantity remaining is less than the minimum replacement unit.
	(4) Material required for immediate use to repair unserviceable repairable items identified as high value items or critical items by ASO/NAVAIR.
	(5) Items required to effect replacement or repair of physical plant facilities in an Intermediate Maintenance Activity without which the effectiveness of the facility is impaired.
	(6) Items required for immediate installation to effect repair or replacement of auxiliary equipment without which the effectiveness of the assigned mission is impaired.
	(7) Required to preclude an anticipated work stoppage in performing maintenance on mission essential equipment. The work stoppage is anticipated within 12 days by CONUS activities and 17 days by overseas activities.
C	(1) Items required to repair or replace administrative support equipment or systems not immediately essential to operational mission of aircraft or organization units.
	(2) Items required for routine stock replenishment.
	(3) Items required for scheduled maintenance and repair, not immediately required.

NOTE 1: Requirements of this nature are of such a consequence as to require a report to higher authority of a degradation of the requestioning unit's capability in accordance with established NORS procedures.

For example, if a squadron or unit has been assigned force/activity designator III and a work center supervisor determines that a part or some material is needed which, if not received, will impare the capability of the aircraft to perform its assigned mission, then the priority assigned must be 03, 06, or 13. Referring to table 2-3, item B (2) describes this particular work center supervisor's situation; therefore, the urgency-of-need designator will be "B" and the priority must be 06.

There are allowable exceptions to the force/activity designated governed priority number system. Medical or disaster supplies and essential clothing may be requisitioned under priorities 03 and 06, respectively, by any activity regardless of its force/activity designator.

MATERIAL TURN-IN

There are two main reasons for turning in material—the first and most common is the turning in of a damaged, wornout, or otherwise inoperative part in exchange for a like RFI item; and second, returning of material for credit, such as excess material or material received in error.

When it is determined that a needed part is an exchange item, the old part should be cleaned of grease and dirt, drained, flushed, or purged as necessary before turning it in. It is the responsibility of the maintenance personnel to attach aircraft equipment condition tags directly to the repairable item. An aircraft equipment condition label is applied to the exterior of the container. All turn-in material should be returned, if practicable, in the container in which the new item was received.

Activities placing items into shipping containers are responsible for the accuracy and completeness of information on the tag and the label, including the necessary obliteration of previous markings on the container which no longer apply. The primary reason for these tags and labels is to provide a means of identification and condition without disruption of packaging or preservation. These tags and labels indicate the required disposition to those processing the material through channels.

When a defective repairable item is turned in, the following forms are required: copies two, three, and four of the multicopy Maintenance Action Form and the Accessory and Component Service Record, when applicable. The supply department uses copy two of the MAF for book-keeping purposes. Copies three and four of the MAF accompany the item to the Intermediate maintenance activity. When repair is completed by the IMA, copy four of the MAF is attached to the RFI item and the item is returned to the supply system.

If material being turned in is no longer required and is RFI, a Single Line Item Release/Receipt Document (DD 1348-1) is submitted with the item. RFI means ready for issue in all respects—preservation still intact and item in original or reusable container with seals unbroken.

Parts Kits

Supporting items and material for the maintenance, repair, and rework of selected repairable type items are procured, stocked, requisitioned, accounted for, and used on a kit basis as a single item. These parts kits should not be confused with Change Kits which are issued to perform a one-time modification of an item, nor with Interim Fleet Maintenance Support Kits which consist of a minimum range and quantity of parts and material to support the items until regular parts kits become available as a result of normal provisioning action.

A repair kit consists of a group of maintenance or overhaul parts that are bought, packaged, and stocklisted as a single item regardless of the supply classification of the items contained in the kit. Normally, these parts have either a very low unit cost or have a high replacement rate in overhaul or repair of the next higher assembly. Depending upon the complexity of the item to be repaired, there can be one or more kits needed for its repair. Repair parts kits are designed to serve three separate requirements as described in the following paragraphs.

C KIT (CURE-DATED OR SOFT GOODS).—This kit provides cure-dated items such as diaphragms, packings, and O-rings. The C kit may also contain soft goods not subjected to age controls such as gaskets and seals, plus metallic items such as screws, nuts, and washers required to be removed when cure-dated or soft goods type material are replaced. When mixed

categories of cure-dated parts are packaged in a single container, the controlling cure-date of the package is that of the oldest cure-dated part in the package. If cure-dated kits become over-aged due to the expiration of the storage limitations, the kit is administratively disposed of as excess materiel.

D KIT (OVERHAUL).—This kit contains hard good repair parts required at the time of overhaul. This kit does not contain cure-dated parts nor any metallic item which is placed in the C kits, thus both are required at the time overhaul maintenance is being performed.

F KIT (FLEET).—This kit provides those items that are required to be replaced at Intermediate and Organizational maintenance levels. Replacement of F kit items normally does not require special tools or equipment. This type kit does not contain cure-dated parts.

Part numbers for repair kits are listed in the applicable Illustrated Parts Breakdown and, in some cases, the Maintenance Instructions Manual.

CHAPTER 3

WORK CENTER SUPERVISION AND ADMINISTRATION

A Chief or First Class Aviation Machinist's Mate J is likely to be assigned the responsibility of supervising a work center. The work center could be at either the Organizational or the Intermediate maintenance level and might include the line division, quality assurance division, maintenance control, or powerplants.

The importance of the supervisor to the success of an organization cannot be overemphasized. He is the link between policy making and policy execution. The supervisor is primarily concerned with seeing that the job is done, not necessarily performing the work himself. His duties consist primarily of planning and directing the workload and maintenance management of the manhour accounting system within his work center.

Although this chapter deals primarily with the problems of the powerplant work center supervisor, the objectives presented, the problems involved, and the methods of dealing with them may be applied to other supervisory billets to which the ADJ might be assigned.

SUPERVISOR REQUIREMENTS

The AD in a supervisory position sets in motion the plans, schedules, and policies of his superiors. His primary concern is seeing that the job gets done, rather than performing the work himself.

To accomplish this end, the supervisor must know his men, assign them work within their capabilities, direct their efforts, and assume responsibility for seeing that each job is done correctly.

The supervisor's objectives are to operate with maximum efficiency and safety, to operate with minimum expense and waste, and to operate as much as possible free from interruption and difficulty. These three objectives are amplified in Military Requirements for Petty Officer 1 & C, NavPers 10057 (Series).

It is important that an AD assigned supervisory duties keep in mind the importance of his new assignment to him personally. It affords him the opportunity to gain practical experience for future promotions. His duties cannot be approached in a haphazard manner. To make right decisions, the supervisor must be knowledgeable, possess integrity, and utilize common sense. He should employ the principles of good leadership in carrying out his assignment. The information provided in Principles and Problems of Naval Leadership, NavPers 15924 (Series), will prove invaluable to the new supervisor until he has gained more experience.

KNOWLEDGE

Effective supervision of a work center requires a competent degree of knowledge concerning all areas of aircraft maintenance that could affect the work center. The senior petty officer must keep abreast of new ideas and be aware of the variety of directives and publications that regulate his actions. He must be knowledgeable of the factors that make him a maintenance manager, of the programs that affect his work area, of his rating, and the weapon system being supported.

Maintenance Management

The Naval Aviation Maintenance Program (NAMP), OpNav 4790.2 (Series), outlines command, administrative, and management relationships and establishes policies for assignment of aviation maintenance tasks. As defined in this instruction, the work center supervisor is responsible for the following actions:

1. Insuring the accomplishment of all assigned work.

2. Insuring maximum utilization of personnel and facilities.

3. Making recommendations concerning work center repair capabilities and facility requirements.

4. Causing all work to be inspected as required.

5. Initiating of material requirements to support the workload.

6. Screening of all source documents, work requests, and associated paperwork to insure accuracy, completness, and timeliness of submission.

7. Keeping maintenance control informed of work status.

8. Reviewing of daily manhour (when applicable) and maintenance data reports for accuracy and submission of necessary corrections.

9. Insuring that the maintenance department training program is properly supported within the work center.

The supervisor who endeavors to become thoroughly familiar with the contents of the Naval Aviation Maintenance Program Manual, volumes I [illegible] will be better equipped to handle the administrative affairs of the work center. By the time most petty officers reach E-5 level, they should be totally familiar with the variety of source documents associated with aircraft maintenance. Use of these documents is covered in Military Requirements for Petty Officer 3 & 2, NavPers 10056 (Series). Military Requirements for Petty Officer 1 & C, NavPers 10057 (Series), provides coverage on the various manhour and maintenance data reports as well as other pertinent areas of the NAMP.

Special Programs

The senior AD will by necessity become involved in the variety of special programs that directly or indirectly affect the supervision of his work center. OpNav Instruction 4790.2 (Series) provides amplifying information on selected maintenance programs such as the following:

1. Component repair.
2. Foreign object damage (FOD) prevention program.
3. Corrosion control and preservation.
4. Oil analysis program.
5. Aircraft fuel surveillance.
6. NavAirSysCom calibration program.

Separate chapters provide in-depth information concerning Quality Assurance, Unsatisfactory Material/Condition (UR) Reporting System, Planned Maintenance System, etc.

Rating

The supervisor who has had varied experience in all aspects of his rating is a definite asset to any command. A complete knowledge of one's rating is not easily achieved. All too often, personnel put in the required training courses and rely on the information retained from the Rate Training Manual to get them by. Study of the latest editions of these manuals and the additional reference material listed in NavTra 10052 will assist in the never-ending attempt to stay current. When advancement in rating qualifications change, the alert petty officer notes these changes and strives to correct any knowledge deficiencies that might exist. Curiosity regarding activity correspondence, changes and bulletins, changes to maintenance publications and other maintenance directives, as well as changes to other sources of information which affect the supervisor's work center and/or rating can result in increased ability and confidence.

Weapon System Being Supported

The number of aircraft accidents, ground accidents, and incidents involving maintenance errors has increased steadily for the past several fiscal years. As the number of errors increased, the most often repeated errors continue to be the same from year to year. Some of the errors cause little or no damage and consequently have not been appropriately advertised. Many maintenance errors can be attributed to failure of the supervisor to properly perform his duties.

A knowledge of the weapon system being supported is a must requirement. The training lectures prepared for use in training personnel within the work center should be a valuable source of information regarding the weapon system. Study of the appropriate volumes of the Maintenance Instructions Manual and completion of courses on the weapon system provided by Naval Aircraft Maintenance Training Groups (NAMTG), which have detachments in the field, will better equip the supervisor to make decisions regarding maintenance of the system. Use of the MIM when performing maintenance applies to both the worker and the supervisor. The complexity of many of today's aircraft

systems requires that step-by-step procedures be followed for accomplishing removal, installation, repair, operational testing, etc. It is impossible to commit these step-by-step procedures to memory. Personnel who are unfamiliar with a task that is assigned should readily admit their lack of proper training rather than attempt the task with questionable results. It is not uncommon for a supervisor to find that a subordinate has greater knowledge of a particular system than the supervisor. However, the supervisor must make it a habit to verify any doubtful information and correct any knowledge deficiencies on his part, or he may lose some of the respect necessary to maintain control of his men. This is not to imply that he should be distrustful of his men. Sometimes subordinates feel that information passed on to them by others is correct without verifying it in the MIM. In summary, it is better to admit when you do not know something and then follow through by doing something about it immediately.

SUPERVISION AND LEADERSHIP

The experienced petty officer will soon learn that supervision and leadership are very closely related. The supervisor's role requires that he be a leader, a man of common sense, and a man who earns the respect of others. Many decisions are difficult to make. To be effective in his decision making, the supervisor assembles pertinent facts, policies, and procedures; developes a course of action and evaluates possible alternatives; selects the best course of action; and initiates the required action. When necessary, he consults his own superior prior to taking action. Every supervisor must face problems squarely and make timely and sound decisions. The supervisor who dodges his responsibilities will soon find his control of subordinates slipping away, discipline deteriorating, dissatisfaction with his supervision increasing and effectiveness of the organization suffering.

The supervisor who establishes and maintains a spirit of cooperation within his work center and in the everyday dealings with other work centers and maintenance control will find his job is much easier. Aircraft readiness is the common purpose of the maintenance organization, and all ratings should share a common interest in achieving that purpose. A willingness by each individual to submerge his personal interest in favor of getting the job done is a necessary prerequisite to cooperation. If the supervisor's requests are reasonable, made well in advance (when possible), were understood, and provided all necessary information, his requests will generally induce cooperative action. If cooperation is lacking, check the facts to find out why. If subordinates are at fault, they can be told directly and in a firm manner, taking into consideration the basic principles of good leadership.

The supervisor's duties involve planning, direction, and control. Careful planning is an essential ingredient to effective supervision and minimizes other types of supervisory efforts when carefully executed. Time and effort invested in the process of careful planning is rarely wasted. It can result in job simplification and increased efficiency.

The effective supervisor initiates the planning process by identifying each specific job to be done by his men. With a routine clearly established, he can spend his time on the exceptions that may arise. He knows the capacities, interests, weaknesses, and potentials of his men. Knowing each man's level of technical skill, motivation, ambitions, and personality characteristics will enable the supervisor to (1) assign the right man to the right job, (2) identify the training needed by each man to do a better job, and (3) establish the standard at which each man can be expected to perform.

Once action has been initiated, the supervisor provides direction. This function of supervision is like that of a "foreman." He sees that work is started and knows what is going on at all times. This does not mean that he must always be physically present while the job is being done. Subordinates should be trained to assume responsibility for the job in the absence of the supervisor so that no man is indispensable, including the supervisor. The supervisor should, however, be available when his men are working, and they should know how to contact him. The supervisor should always be present when his men are assigned new tasks, when they have trouble getting a job done, or when other circumstances dictate the necessity for his presence. He must be careful not to oversupervise lest he destroy the initiative of his workers and subordinate supervisors. He receives suggestions and reactions from his subordinates and acts as necessary on them, giving credit when and where it is due. Recognition of each man as an individual is required.

Control of a job refers to the function of checking to see that the job is done as planned—a comparing of performance with plans. Deviations may reflect poor planning. However, procedures should exist whereby changes in plans that could result in improved performance can be implemented to minimize repetition of faulty performance.

The supervisor will be challenged to allocate sufficient time to be expended on planning, direction, and control. A spirit of firmness, fairness, cooperation, decisiveness, harmony, and mutual respect while seeing that the job is done will rarely go unrewarded.

Communications

The area of communications as related to supervision and leadership is singled out here because of its importance. Almost without exception, problem areas regardless of their nature can be attributed to the lack of proper communications. Men like to be kept informed about all the things that affect them. Keeping them informed will improve their morale and generally make them more responsive to the needs of the command. The supervisor can improve morale by keeping his men as well informed as possible concerning need-to-know and nice-to-know information that could affect them, as long as it is not classified.

Communications is a two-way process. The supervisor must be able to convey his ideas, orders, etc., and pass on information, either orally or in writing, in such a manner that it will be clearly understood. He must also be willing to listen to and try to understand the ideas of others. Subjectivity (that is, looking at things only from a personal viewpoint, because of your position, rating, pay grade, or any other reason) will hinder communications. Bias and limited knowledge can limit a supervisor's ability to be objective, and by recognizing this fact, he can listen more objectively.

Ridicule, sarcasm, vulgarity, etc., have no place in good communications. The supervisor who must get loud and resort to such language to get his point across or the job done needs to realize how adversely such action affects his own feelings of importance and respect. When it becomes necessary to orally reprimand a subordinate, do it in private, keeping in mind that he is an individual and as a petty officer he must have the respect of the men under him. If a supervisor reprimands a man in public, both lose respect and are less effective in getting the job done.

Professionalism

It is the responsibility of all senior petty officers to install a spirit of professionalism in their subordinates. Aircraft maintenance is a reasonably complicated profession that leaves little room for error. The maintenance man who gives it less than his undivided attention presents a potential hazard. Of primary importance are the ethical attitudes and considerations involved in performing each maintenance task, the unspoken but carefully adhered to codes governing each man's action.

The responsible petty officer sets the example he wishes others to follow, doing the right thing in carrying out each assignment, including (and especially so) when no one is watching. Undiluted professionalism means that there is no room for ethical lapses or occasional breaches of integrity. The worker who even once shortcuts established procedures, does not follow maintenance manual instructions, sacrifices quality for speed, or performs any other action which could produce a negative judgement towards him lacks the professional integrity demanded in aviation maintenance. The supervisor who condones such action is equally guilty of a less than professional attitude and the results that such actions could cause.

There is no substitute for thorough knowledge of your aircraft, your job, and the procedures associated therewith. Correct maintenance procedures and thorough quality assurance will almost always produce professional results. Aviation safety demands pure, undiluted professionalism from all personnel involved in maintenance.

WORK SIMPLIFICATION

Work simplification is a common sense, systematic method of identifying and analyzing work problems, developing solutions, and installing improvements. In order to achieve maximum efficiency each supervisor must do his part to improve the work situation and achieve maximum manpower utilization. This implies that the greatest possible use of all resources available be made in order to help accomplish an activity's mission. Work simplification is a tool which can be utilized effectively in the

accomplishment of this goal. Work simplification might be considered as human ingenuity applied to the work situation. It is the organized use of common sense and creative thinking in the solution of work problems.

If all men had believed that there could be no better way of doing things, we might still be throwing rocks at game for our food and traveling from place to place on foot. Progress in these fields was not made in a single step but in a series of improvements. These changes occurred slowly over the centuries, growing out of a multitude of small improvements.

The supervisor who lives day to day, satisfied that what he did yesterday is good enough for tomorrow, will, in most cases, leave his job no better from having held it. He leaves nothing significant for other personnel to follow him in his job, and he becomes lost in the shuffle of men who are content with merely living and dying.

The majority of improvements in our world did not come by accident; rather, they came as a result of man's ingenuity, growing out of his sense of imperfection and his constant search for improvement. When an improvement is made, no matter how small, it marks its discoverer as a person of imagination with a real and active interest in his work.

The supervisor who believes in and practices work simplification procedures can look with pride upon his contributions or those of people who work with him. This means that the supervisor should never cease to search for improvement and must encourage his workers to try to improve jobs over which he has control.

The supervisor should always watch for areas where work can be simplified. Work simplification pays immediate dividends by increasing both production quality and quantity. It allows the supervisor to meet work schedules more easily and reduces waste by producing with less effort, increases savings in time and man-hours, and thus reduces cost of operation. Work methods improvement aids in establishing standard procedures. These standard procedures aid in training both old and new workers, since most workers are easier to train, and learning is much easier if standard practices are used.

It is true that with good leadership personnel can be encouraged to work to the limit of their physical endurance but unless their efforts are used wisely, the most critical resources—manpower—is being wasted. In the final analysis, it is not how hard personnel work but how much quality work is accomplished that matters. Therefore, to help achieve maximum results with minimum expenditure of human effort, the supervisor should always strive to use established work simplification techniques.

Work simplification permits continuous evaluation by analyzing existing methods and procedures with a view toward improving them. There is always a better way of performing a task by using streamlined methods, improved tools, better working conditions, or shorter procedures. However, these better methods are not always apparent. Work simplification should be directed at all work situations where physical effort is expended.

Techniques

There are many techniques for improving work methods. For the most part, these techniques are adaptable to any part of an organization as well as a whole activity. Five of the principal techniques which have been successfully applied to work operations are discussed briefly in the following paragraphs. All of these techniques require the construction, completion, and use of lists, charts, flow diagrams, etc., in order to study and analyze specific areas.

WORK DISTRIBUTION ANALYSIS.—Work distribution analysis is a technique used to analyze objectively the division of work in an organization. In order to obtain the most effective distribution of work, it is necessary for the supervisor to have an overall view of the organization and its operations. The supervisor must clearly understand the work that is being done and be able to see the relationship between the overall operation and the individual work units as well as the contribution that each person makes to the work of the whole organization.

Distribution of work is an important factor in efficient use of manpower. Time and effort are saved if related duties are performed by the same person. Thoughtful matching of assignments and qualifications is important so that personnel are not struggling with work that is too hard for them or wasting their time on tasks that might be performed by a less skilled person. Another consideration is distribution of workload to avoid inequalities, since these result in bottlenecks and other inefficiencies.

Work distribution analysis requires that a Task List be completed for each person whose

work is being studied. This list contains, in simple statements, tasks the worker performs regularly and the average number of hours spent on each task per week. Next, a Function List is prepared which lists each function performed by the unit. Each task reported on the Task List must be related to a specific function. A Work Distribution Chart is prepared from the data collected on the Task List and Function List. This chart presents the work performed in the existing organization under current operating conditions. The chart is then studied and analyzed to find answers to questions such as the following:

1. What functions take the most time?
2. Is there misdirected effort?
3. Are skills being used properly?
4. Are personnel doing too many unrelated tasks?
5. Are tasks spread too thinly?
6. Is work distributed evenly?

A careful study and analysis of the work distribution chart should assist in achieving the following results:

1. Elimination of unnecessary tasks.
2. Reduction of time spent on relatively unimportant functions.
3. Elimination of duplication and overlapping of work.
4. Better balance of workloads.
5. Combination of related tasks.
6. Realistic estimate of personnel needs.
7. Better utilization of skills.
8. Reallocation of misassigned personnel.

WORK COUNT ANALYSIS.—Work count analysis supplements the work distribution analysis and is a technique for determining the volume of work in terms of measurable units. Information obtained by counting or measuring the work provides a basis for improving methods and procedures, adjusting work assignments, evaluating performance, and eliminating bottlenecks. Such information is useful in assigning and scheduling work to insure that the workload is equitably distributed among all personnel.

Items of work counted should be definite and comparable. Items counted should also be representative of work usually performed. Only those should be counted that clarify methods employed. Counting may take place where the work comes into Production Control, where a decision is made or action is taken, where a process is completed, or where long storage occurs.

Work count information can be used to accomplish the following:

1. Establish how long it takes to do a given piece of work.
2. Indicate whether the volume of a certain piece of work is sufficient to warrant specialization.
3. Show whether work is distributed evenly among workers.
4. Point out bottlenecks where work piles up.
5. Indicate whether the work center is adequately manned, overmanned, or undermanned.
6. Stimulate interest of personnel by providing comparisons of one person's work with that of another or with his own record during a different counting period.

FLOW PROCESS ANALYSIS.—Flow process analysis is a technique for analyzing flow and sequence of operations. The purpose of this analysis is to reduce time and distances in a process by eliminating, combining, and changing the sequence of steps in the flow of work.

The principal tool of this technique is the construction of a flow process chart which provides a clear and detailed picture of the flow of work. Recording each step in a procedure helps to identify duplication of effort, backtracking, and other obstacles to the smooth, efficient flow of work.

MOTION ANALYSIS.—Motion analysis is a technique for making maximum use of physical motions. It is a method of studying the motions of individuals in performing their various tasks.

Work distribution and flow process analyses are directed toward improving the division and flow of work. Motion analysis deals with how an individual performs his tasks. It seeks to learn whether the workers are doing their work with minimum fatigue, loss of time, and waste of effort. Improvements are effected by rearrangement of materials and work area and by proper use of equipment.

The simplest way of gathering data for motion analysis is for the supervisor to watch his personnel at work and note useless motions. Motion analysis should result in the elimination of wasteful motions and consequent loss of work time, reduction of fatigue by lessening the amount of physical effort required to complete a task, and increase the efficiency of personnel.

LAYOUT ANALYSIS.—Layout analysis is a procedure designed to lead to better utilization of space, personnel, and equipment. A study of the layout of a working area can provide useful

information for improving the work of individuals, distribution of the workload, and flow of work from one person to another. Its purpose is to determine what space is needed for the operations to be performed and how the available space may be used most effectively. Besides shortening and simplifying motions, it should produce working conditions that are as comfortable and personally satisfactory to the workers as possible consistent with efficient and economical operation.

The layout chart is the principal tool of this type of analysis. This chart consists of a floor plan of the work space, showing doors, windows, electrical outlets, etc. All features that restrict usable space should be included.

The following principles should be kept in mind when studying a work center layout chart:

1. Equipment getting the most use should be located in the most accessible areas.
2. Layout should provide for safe use of equipment.
3. Arrangement of equipment and facilities should allow for effective supervision.
4. Arrangement of equipment should accommodate the necessary flow of personnel utilizing the work area.
5. Maintenance publications should be conveniently accessible to those who use them.
6. Working space allocations should be consistent with working conditions.

INSTALLATION OF IMPROVEMENTS.—Briefly speaking, work simplification means improving methods of doing work or finding a better way. Improved methods usually involve eliminating unnecessary parts of the job, combining and rearranging other parts of the job, and simplifying the necessary parts of the job. By improving methods personnel are able to do better work, with less effort, in less time, without hurrying, with greater safety, and with lower cost. The pattern for achieving the benefits of work simplification is as follows:

1. Select the job to be improved.
2. Break down the job in detail.
3. Question the job and each detail of the job.
4. Develop the new method.
5. Apply and install the new method.

The fact that changes are recommended as a result of a work simplification study does not always mean that these changes will or can be made immediately. There are several reasons why a change that many regard as an improvement may be slow in being adopted.

Most any change will draw objections from a certain number of persons. There are two general types of reasons for these objections. First, many people regard a recommended change as a criticism of the way they have been doing their work and therefore resent it. Most of this type of objection can be avoided if those who will be affected by the change can participate in some degree in the analysis so that the whole enterprise becomes a group activity. If this is not possible, at least a clear explanation should be made regarding reason for the change. Emphasis should be on future advantages rather than criticism of old methods. Secondly, most people have a natural dislike to changing established work habits. If advantages of the new method are clearly explained, this resistance lessens considerably.

Before making any changes it is well to consider carefully all likely effects, for sometimes unforeseen effects may cancel out the beneficial aspects of the change. It is important, for instance, when new equipment or facilities are contemplated, to be sure that advantages of the new installations will outweigh cost. Indirect effects of change upon other equipment or conditions should also be considered.

Effects upon interorganizational relationships should also be taken into account. If work procedures are speeded up in one phase of an operation only to create a bottleneck in another, there will be little or no improvement.

PLANNING WORK CENTER ARRANGEMENT

The average Chief or First Class Aviation Machinist's Mate J may never have the opportunity of planning the layout of the powerplant work center in a new facility. In almost every case, the new supervisor will take charge of an already functioning division or else, when his squadron or unit moves to a new base, he and his crew will usually be assigned to spaces already basically equipped for powerplant repair. In either case, a reevaluation of the layout should include finding out from the applicable allowance lists if the equipment allowances have been changed in any way. There is no use relocating equipments which involve rewiring or plumbing work if improved replacement models are authorized and available.

PURPOSE OF THE WORK CENTER

A basic consideration in planning a work center layout is its purpose. When more than one space is available, the supervisor must decide which space would be most suited for a powerplant work center. Of two spaces identical in size, one may, for example, be completely unacceptable for powerplants due to the location and size of doors or the shape of the area.

A change in assigned aircraft model designation always calls for a reevaluation of the work center arrangement. Work centers in activities assigned A-4 aircraft may have to be rearranged somewhat if the A-4's are replaced by F-4 or RA-5C aircraft.

The general function of the work center must be considered in the allocation of space and equipment. The ideal work center would contain enough space to have workbenches, engine stands, engine buildup, parts and tool stowage space, propeller section (if required), and ample space for technical publications in a centrally located area. Since this is not normally possible, the supervisor must decide what sections of the work center are to be combined and in what areas of each space the appropriate equipment is to be installed. This decision should be based on factors of safety, economy, functional compatibility, and convenience.

ARRANGEMENT

Following the determination of which work center is to occupy which space or area within a space comes the arrangement of furniture and equipment.

The arrangement of the work center furnishings should be made on the basis of utility rather than appearance. Moving an item of equipment into an out-of-the-way corner may greatly improve the appearance of the work center but at the same time reduce the efficiency of the personnel using the equipment and may possibly create a safety hazard. A good rule to follow is to locate equipment where it can be safely used by the greatest number of people with a minimum of effort in the least amount of time.

Worktables and workbenches should be positioned with respect to fixed equipment so that the equipment most often used is most quickly and easily reached. Electrical and compressed air outlets should be readily available to the workbenches. Needless delays are caused by having to rig unnecessarily long connections from poorly located outlets.

Near workbenches where specific and intricate maintenance functions are performed, consideration should be given to installing special lighting such as explosion-proof, vapor-proof, or interference-free type lighting. Under certain conditions, special lighting may also include floodlights for outside work areas and in hangars when improved lighting is required.

Utilization of paint in various colors to emphasize portions of intricate machinery for safety and reflective purposes is known as dynamic painting. Painting in this category should not be utilized for normal building maintenance.

A system of stowing tools must be devised. An intelligent system cannot be set up without first determining from allowance lists what tools will be required for satisfactory operation of the work center. The place for all tools should be marked or otherwise specified, and everything not being used should be kept in that place.

The layout should make provisions for a bulletin board upon which may be posted safety posters, maintenance posters, instructions and notices, plans-of-the-day, and such other information as is appropriate from time to time. The bulletin board should be located in a prominent place in the work center, preferably near the entrance where everyone assigned will have to pass some time or another during the day. Material on the bulletin board should be changed frequently, expired notices promptly removed, the current plan-of-the-day posted early, and other posters and material rotated periodically. If the same material is presented in the same format every day, it will not be long before the men begin to ignore the bulletin board and purposes for having it are defeated. New arrangements are noticed and interest is stimulated with variety.

When aviation Organizational level maintenance activities are moved aboard ship, their working conditions and accommodations are drastically affected. The ingenuity of the supervisor will be required to produce a workable arrangement within very limited spaces. Stowage racks for toolboxes and other work center equipment should be located to accommodate their frequency of use. Some equipment used at less frequent intervals may have to be stowed in voids. An inventory listing of such items, showing their specific location, will be necessary.

Security of material stowed in voids, toolboxes, and other equipment will require more attention than when ashore. Gear not properly stowed and afforded appropriate security has a habit of disappearing, and during rough sea states, can be hazardous to personnel and/or other equipment.

Much of the work done aboard ship will have to be done under less than ideal conditions. Confined spaces, reduced lighting during night time flight operations, hazardous conditions on the flight and hangar decks, problems associated with respotting of aircraft to accommodate maintenance, and a variety of conditions peculiar to ship operations will require modifications of procedures used ashore. The supervisor should insure that spaces are utilized to their fullest extent.

Since most Organizational level maintenance is "on aircraft" type maintenance, the limited space of the work center should present only a minor problem concerning the stowage of gear and some personnel congestion during periods when personnel are awaiting work. Consideration of the factors previously discussed under "Work Simplification," and further discussed in NavPers 18359 (Series), could result in a smoother transition from shore to shipboard facilities and vice versa.

SCHEDULING AND ASSIGNMENT OF WORKLOAD

Among the most important factors with which the Chief or First Class Aviation Machinist's Mate J is concerned as a supervisor are the assignment and accomplishment of the scheduled workload. His objective is the satisfactory completion of assigned tasks in a reasonable length of time, utilizing available men and materials as efficiently as possible. In order to achieve his objective, the supervisor must become skilled in estimating the amount of time to allow for the completion of each task and estimating the number of workers required. He must realize the importance of assigning both qualified and unqualified men to the jobs, consistent with his training program. The supervisor must allow for planned interruptions and yet not operate on so tight a schedule that minor, unplanned interruptions completely disrupt his schedule.

ESTIMATING TIME AND PERSONNEL REQUIREMENTS

Most maintenance jobs are of such a nature that the quality and quantity of people assigned to do them directly affect the time that will be required for completion. For this reason, time requirements and personnel requirements are combined and discussed together in this section.

Probably the most important single aid in estimating time and personnel requirements for aircraft maintenance tasks is the Periodic Maintenance Requirements Manual with its related cards, charts, and forms. Extensive time and motion studies of the various inspection requirements have been made and completion times are furnished in manhours or manminutes. These times also reflect routine maintenance, adjustments, and replacement if required in connection with the aircraft inspection. They are calculated on the basis that the most efficient number of men are continuously employed and that all necessary equipment, tools, and parts are immediately available. The supervisor must consider all these factors from the knowledge of his individual personnel, supply, and equipment situation, together with an accurate determination of the extent to which the maintenance task at hand exceeds the inspection requirements if he is to reliably predict the completion time. While this procedure may seem rather involved at first, the new supervisor will find that it is based on sound management principles and that, with experience, his ability to accurately predict time and personnel requirements will speedily improve.

PERSONNEL WORK ASSIGNMENTS

Work assignments should be rotated so that each man will have an opportunity to develop his skills in all phases of the ADJ work. When assignments are rotated, the work becomes more interesting for the men. Another good reason for rotating work assignments is that if one highly skilled man performs all the work of a certain type, the supervisor and the work center would be at a great disadvantage in the event the man is transferred. Less experienced personnel should be assigned to work with him in order to become proficient in his particular skill. Also, in order to broaden his knowledge of his rate, the expert on one job should be rotated to other tasks when there is no immediate need for his particular skill.

Strikers should be assigned to various tasks so that they will acquire experience on all kinds of jobs. A special consideration for the assignment of strikers to jobs is that they should be

assigned progressively to jobs of ascending levels of difficulty. A striker may be a useful assistant on a complicated job, but he may not understand what he is doing unless he has worked his way up from basic tasks.

ALLOWING FOR PLANNED INTERRUPTIONS

During an average workday, occasions will arise when personnel have to leave their working spaces for one reason or another, thereby delaying the completion of the scheduled work. Some delays can be anticipated; some cannot. Among the delays which can be anticipated are training lectures, immunization schedules, flight schedules, rating examinations, meals, and watches or other military duties.

Before making personnel work assignments the supervisor should determine what delays can be anticipated. It may be possible to arrange assignments so that work interruption is held to a minimum. When estimating the completion time of a maintenance task, the supervisor should allow for these predictable delays.

SUPERVISION OF THE USE OF EQUIPMENT

In order to achieve maximum production within his work center, the supervisor must closely supervise the use of equipment used to support the production effort. Such equipment includes service, maintenance, and test equipment.

As the aircraft becomes heavier, faster, and more expensive, the support vehicles and equipment become more numerous, more complex, and more dangerous. Therefore, this area of supervision requires more and more attention. Even though the supervisor goes by the standard rules, every command has problems peculiar to its location and mission. This requires that he be familiar with the directives and instructions published in his command.

The supervisor should take full advantage of all training programs to assure that each worker attached to his work center knows the specific operating instructions for the particular equipment being used. If his work center is engaged in aircraft servicing, he must insure that his workers know the type of aircraft being serviced and the service procedures for that particular aircraft and that they follow these procedures.

The supervisor must be familiar with all tools and test equipment that are normally used in the work center for work which cannot be performed on the aircraft. He must be familiar with the calibration program and insure that all equipment is tested and calibrated as specified.

Safety is of paramount importance in the use of any equipment. The supervisor must be familiar with all safety precautions pertaining to the use of each piece of equipment and insist that these safety precautions be observed at all times.

Whenever equipment has been used, the supervisor must insure that the equipment is secured and stowed, if applicable, when the work is completed.

ORGANIZATIONAL WORK CENTER REGISTER

One of the duties of the supervisor is maintaining the organizational work center register.

The organizational work center register is a management tool supplied to the supervisor to assist in control of his assigned workload. The form, when properly utilized, will indicate what work is assigned to the work center, the status of the assigned work, and the personnel assigned to accomplish the work. It will also provide information required to initiate maintenance data reporting (MDR) source documents.

The supervisor enters the basic information received from maintenance control in the work center register. The register should be kept current throughout the day, entering names of men and/or crew assigned, and status changes (awaiting parts, in work, pending, etc.). A review of completed pages of the register will enable the supervisor to monitor work accomplished and to determine if maximum utilization, of skills and equipment is being realized. The register may also serve as a source of on-the-job training information.

QUALITY CONTROL

Commanding officers are responsible for the inspection and quality of material under their cognizance. In a maintenance department, the principal force for securing compliance with quality standards lies NOT in the instruments, instructions, or other facilities for inspection, but in the state of mind of maintenance personnel from the commanding officer down to the workers.

Generating quality in a maintenance organization necessitates a sincere interest on the part of commanding officers, plainly evidenced to the officers and men in their commands. Quality further requires that each maintenance officer and supervisor understand clearly how the accomplishment of a quality job contributes to the effective operation of the organization. Quality also requires that each maintenance worker understand not merely a set of specification limits, but also the intent and the need for these requirements.

The quality assurance organization is concerned with three functional areas—quality management, quality verification, and technical publications.

Quality management is monitored by formulating, implementing, and auditing procedures, instructions, and operations to assure compliance with the policies stated or implied within the NAMP Manual. Quality assurance coordinates their efforts with those of the activity's data analysis group to provide information on maintenance practices and results based on facts gleaned from the various maintenance source documents and associated reports.

Quality verification assures that all material processed and actions taken by maintenance personnel meet prescribed quality requirements. Direct inspection of material and operations as they are performed is necessary on a continuing basis to give adequate assurance that all items processed and maintenance tasks completed meet the prescribed requirements. These quality assurance considerations (tests, inspections, etc.) are included in most weapon system Maintenance Requirements Card decks as well as most Maintenance Instructions Manuals and Overhaul and Repair Manuals (03). Quality assurance verification steps are generally called for at various steps during repair progress in addition to verification of the final product.

Since technical information has a direct relationship towards assuring the quality of work performed, the quality assurance division has the responsibility of operating a master technical library and monitoring of dispersed libraries within the various work centers. Dispersed libraries located within the work centers are necessary to place technical information in the hands of the user who is charged with compliance. The quality assurance division monitors the operation of these dispersed libraries, providing new publications, revisions, cancellations, and such other information that may affect the publications held. A change entry certification is utilized to insure that all change and revision material is entered into the directives and manuals of the dispersed libraries within a reasonable time.

Since the responsibility area of the supervisor is the middle ground between management and men, it is incumbent upon him to initiate and administer a quality assurance program. His main objective is to improve the state of training of his men until their mental attitude is such that top quality workmanship becomes second nature. How successful he is in achieving this objective will be determined by his ability and insight in the following areas:

1. The assignment of the proper number of qualified men to do the jobs, plus-on-the-job trainees.
2. Making provisions for adequate on-the-job supervision and inspection.
3. Allowing adequate time to perform safe, high quality jobs.
4. Assuring himself that current directives and publications on safety and aircraft model concerned are available and complied with.
5. Monitoring the training program with respect to timeliness and completeness of coverage. Eliminating out-of-date training material promptly and introducing important new material as soon as possible after receipt without regard to lesson schedules.

These procedures should result in high quality workmanship by powerplants personnel and meeting of specifications and quality standards in the work.

PLANNING FOR ADVANCED BASE OR FORWARD AREA OPERATIONS

A Chief Aviation Machinist's Mate J must be able to prepare for advanced base or forward area operations by estimating aircraft spare parts and supplies, equipment, and manpower requirements for powerplant repairs. In determining requirements for forward area or advanced base operations, it is necessary to consider the following:

1. Mission.
2. Environment.
3. Operating factors.
4. Availability of existing facilities.

A knowledge of the material and manpower requirements as listed in the Advanced Base

Initial Outfitting Lists of Functional Components will be very helpful. The functional component is one of more than 300 standardized units of the system which the Navy has developed to enable it to build and operate its advanced bases in the least possible time and with a minimum expenditure of planning and logistic effort.

A functional component is a list of the requirements for the performance of a specific task at an advanced base, and consists of a carefully balanced combination of material equipment, and/or personnel.

Each functional component is classified according to its primary function into 1 of 11 major groups, including aviation. Each major grouping is identified by letter designation and title; the functional components contained in each are identified by a combination letter, number, and title designation. The major group letter for aviation is H.

H components are designed to provide for maintenance, support, and operation of aircraft in an advanced area under combat conditions, and may be combined with other functional components to form several types of air stations.

Complete information and data are given in the abridged and the detailed outfitting lists for functional components.

It should be apparent to the ADJC that the advanced base requirements may not be exactly as they appear in the Advanced Base Initial Outfitting Lists. In order to use these lists as guides, it will be necessary in most cases to alter or tailor them to fit the individual needs of the unit about to deploy.

Other necessary repair parts, supplies, and equipment may be determined from the outfitting and allowance lists for the aircraft or other weapons system to be supported.

It is quite likely that the powerplants supervisor will be required to advise the personnel office in the assignment of individuals to advanced base or forward area operating units. It would seem logical that the number of ADJ's assigned to deploy be in the same ratio as the percentage of supported aircraft scheduled to deploy. This may be true if the proposed flight hours per aircraft of the detachment exactly equal the planned utilization of the remaining aircraft and if there are no significant environmental problems to be overcome. The list of personnel assigned to deploy should represent a cross section of the skill levels available unless special maintenance factors indicate otherwise. The selection of personnel should be made as objectively as possible so that the deployed unit may function efficiently without working a hard-ship on the home group.

SAFETY

Operational readiness of a maximum number of aircraft is necessary if naval aviation is to successfully perform its mission. Keeping its aircraft in top operating condition is the principal function of naval aviation maintenance personnel. It is essential that maintenance work be performed with a minimum of injury to personnel and damage to equipment and aircraft.

Aircraft maintenance is, to some extent, naturally hazardous due to the nature of the work, the equipment and tools involved, and the variety of materials required to perform many repairs and maintenance functions. Factors which can function to increase or decrease these hazards are (1) the experience levels and mental attitudes of assigned personnel and (2) the quality of supervision of the maintenance tasks. Thorough indoctrination of all personnel is the most important single step in maintaining safe working conditions.

The concept of aircraft maintenance safety should extend beyond concern for injury to personnel and damage to equipment and aircraft. Safe work habits go hand-in-hand with flying safety. Tools left in aircraft, improper torquing of fasteners, and poor housekeeping around aircraft can cause conditions which may claim the lives of flying personnel as well as cause strike damage to aircraft. Safety on the ground is equally as important as safety in the air.

A recent type commander letter states in part, "While the increased complexity of our modern aircraft is a factor, it is noted that a large number of maintenance-error caused accidents and incidents are due, not to complexity of equipment, but to lack of supervision and technical knowledge. Many mistakes are simple ones in routine maintenance."

Safety in aircraft maintenance depends largely upon the supervisory personnel. The standards of quality which they establish are directly reflected in the quality of the aircraft maintenance. The primary duty of the senior petty officers is to supervise and instruct others rather than to become totally engrossed in actual production. Attempts to perform both functions invariably result in inadequate supervision and greater chance of error. Supervisors must exercise mature judgment when assigning

personnel to maintenance jobs. Consideration must be given to each man's experience, training, and ability.

Sometimes overlooked in a maintenance program are the considerations generally grouped under the term "human factors." These factors are important in that they determine if an individual is ready and physically able to do work safely and with quality. Supervisory personnel should be constantly aware of conditions such as general health, physical and mental fatigue, unit and individual morale, training and experience levels of personnel, and other conditions which can contribute in varying degrees to unsafe work. Not only is it important that proper tools and protective clothing and equipment are available for use, but also the insistence by maintenance supervisors that they are used is of increasing importance with modern high-performance aircraft. For example, maintenance personnel are sometimes negligent in the wearing of protective hearing devices in high noise areas.

Technical knowledge also plays a large part in a good maintenance safety program. The complexity of our modern equipment demands the attention of well-informed and expert maintenance personnel; otherwise, our weapons systems cannot be operated and maintained. Technical knowledge is a function of education and training which, incidentally, does not end with graduation from Class A school. Graduation is only the beginning. An ADJ worthy of the rating is continually training and learning through self-study and application, and through a personal desire for proficiency and self-betterment. But technical knowledge by itself is not sufficient unless it is coupled with an old-fashioned craftmanship that receives gratification and keen satisfaction in doing any job well. The ADJ who wishes to contribute to safety and reliability improvement must know his job and must develop professional pride in the quality of his work.

It is a continuing duty of every person connected with aircraft maintenance to try to discover and eliminate unsafe work practices. Accidents which are caused by such practices may not take place until a much later date and their severity cannot be predicted. The consequences may range from simple material failure to a major accident resulting in serious injuries or fatalities.

There are several areas in which the supervisor can effectively work to minimize accidents incident to aircraft maintenance. Among these are continuing inspections of work areas, tools, and equipment; organization and administration of safety programs; correct interpretation of safety directives and precautions; and energetic and imaginative enforcement of them.

INSPECTION OF WORK AREAS, TOOLS, AND EQUIPMENT

Most accidents which occur in noncombat operations can be prevented if the full cooperation of personnel is gained and vigilance is exercised to eliminate unsafe acts. The powerplants supervisor should diligently inspect work areas, tools, and equipment to detect potentially hazardous and unsafe conditions and take appropriate corrective action. The ADJ may be working in the shop, in the hangar, or on the line, and all these areas should be included in the supervisor's inspection. He should check for explosion or inhalation hazards due to improper ventilation of working spaces or careless handling of materials.

Fire hazards present another serious problem. "No Smoking" rules should be strictly enforced. Ground wires should be installed on every aircraft during maintenance to eliminate dangerous static electric buildups. Spilled oil, grease, and chemicals should be wiped up promptly, and all rags used should be disposed of in covered metal containers.

Handtools should be in good shape, of the proper type, and used only for the purpose for which they were designed.

Insure that equipment is operated only by qualified personnel, and that all safety devices and guards are installed and in good condition. The equipment should also be inspected for broken or damaged components. Check to see that periodic maintenance, servicing, and/or calibration are up to date for those equipments requiring it. Details on the Naval Air Systems Command calibration policy are contained in NavAir Instruction 4355.4 (Series).

ORGANIZATION AND ADMINISTRATION OF SAFETY PROGRAMS

In accordance with the Navy policy of conserving manpower and material, all naval activities are required to conduct effective and continuous accident prevention programs. The organization and administration of a safety program applicable to powerplant work centers are part of the requirements of the powerplant supervisor. The safety program must be in

accordance with applicable instructions. Work methods must be adopted which do not expose personnel unnecessarily to injury or occupational health hazards. Instructions in appropriate safety precautions are required to be given and disciplinary action taken in case of willful violations.

The safety program will generally involve three areas of attention—the posting of the most important safety precautions in appropriate places, the incorporation of safety lessons in the formal training program, and frequent checks for understanding during the day-to-day supervision of work.

Posted safety precautions are more effective if they are easily complied with. For example, a sign on a tool grinder reads "goggles required," so one or more pairs of safety goggles should be hanging within reach at the machine. Similarly, the protective clothing poster in the welding shop should be backed up with readily available aprons, gloves, shields, etc.

Fixed posters and signs should be renewed frequently and not allowed to become rusty, faded, or covered with dust and dirt. General safety posters on bulletin boards and other places should be rotated often to stimulate interest. Appropriate safety posters may be obtained from the squadron or unit safety officer.

The formal safety training sessions should utilize films, books, visual aids, or any other suitable technical material. The men should be told more than just what or what not to do. Each safety subject should be explained in detail. The result of unsafe acts are usually the most dramatic and easiest remembered. Causes of accidents and contributing factors should be reviewed and analyzed. Many good ideas for accident prevention have been developed in training sessions.

An extensive series of lessosn may be developed over a period of time as latent hazards are recognized; this will aid in keeping the sessions interesting while avoiding frequent repetition.

It may be well to mention the new man in the work center at this point. A separate safety indoctrination lesson which covers all the major hazards of the work center should be given the new man as soon as he reports for work. No supervisor with an effective safety program and an excellent work center safety record wants to take the chance that the new man will be hurt before attending the complete series of safety lessons.

In the third area of safety program administration—followup—the supervisor will do well to delegate authority to his subordinate petty officers to assist him in monitoring the program. Also included in the followup area is a responsibility of the supervisor to inquire as quickly and thoroughly as possible into the circumstances of accidents and reports of unsafe practices and take action or make recommendations.

INTERPRETATION OF SAFETY DIRECTIVES AND PRECAUTIONS

The safety precautions in Department of the Navy Safety Precautions for Shore Activities are designed to cover usual conditions in shore activities. Commanding officers and others is authority are authorized to issue special precautions to their command to cover local conditions and unusual circumstances. The supervisor will have to apply both sets of rules in the administration of his safety program.

Safety directives and precautions should be followed to the letter in their specific application. Should any occasion arise in which any doubt exists as to the application of a particular directive or precaution, the measures to be taken are those which will achieve maximum safety.

When new safety posters or precautions are posted, it is the responsibility of the supervisor to correctly interpret their application to his men. In this way he will be able to achieve a unity of thought and action in the observance of the required safety rule.

The organization's safety officer is available to assist in interpreting and suggesting ways of implementing various safety directives and precautions. Current directives require that a safety officer or safety engineer be assigned as head of the safety department, division, branch, or section, whichever is applicable, at all shore stations.

In most instances the hazards involved and the applicable precautions for a given type of work are the same whether the work is done afloat or ashore.

POWERPLANT INSPECTIONS

The supervisor should insure that for each maintenance action, qualified personnel are assigned, proper tools are available, and proper techniques are employed. The supervisor must also conduct an effective training program for personnel assigned. During most calendar

inspections, the powerplant is removed from the aircraft and taken to a centrally located space to accomplish the inspection. This enables the supervisor to closely monitor the check himself or with collateral duty inspectors. It also affords the supervisor an opportunity to initiate on-the-job training.

Maintenance Requirements Cards (MRC's) are used for periodic inspections. The MRC's provide the maintenance man a ready reference to perform the scheduled maintenance on the powerplant. Each MRC contains one or more detailed maintenance requirements. Illustrations, clearances, tolerances, charts, and part number are included when required. All minimum requirements for the accomplishment of any particular periodic maintenance task are contained in a set of these cards.

Frequent and thorough inspections are necessary to attain efficiency and safety. Working spaces should be checked for cleanliness. By conducting an effective training program and insisting on keeping the working spaces clean and orderly, the supervisor is encouraging orderly thought and systematic work habits which will be directly reflected in high quality workmanship.

Work priorities are centrally controlled by Maintenance Control. Supervisors at every level must know which job is to be given emphasis; thus, work assignments can be controlled and production effort applied to desired projects. Each job is assigned one of the following priorities: Priority 1, Immediate Action; Priority 2, Urgent Action; or Priority 3, Routine Action. Work priorities may vary hourly or daily, depending on the flight schedule and the unscheduled maintenance workload. The supervisor must insure that maintenance control is continually informed of the status of assigned work. He must also insure that quality assurance inspections are performed as required.

TECHNICAL SPECIFICATIONS

The powerplant inspection refers to an inspection to determine the quality and completeness of work performed and material condition. The control of quality is the duty of each division and each individual. It is the task of the quality assurance division to aid the various work centers in the maintenance department in performing this duty. The supervisor must recommend only the best qualified men in this work center to be designated collateral duty inspectors to insure that all weapons systems are maintained to the maximum extent possible.

The responsibility of the supervisor has increased in difficulty with the ever increasing complexity of the aircraft. More and more technical specifications and requirements must be met. It is almost impossible for the supervisor to remember all the technical requirements with which his work center must comply. This can be accomplished by a through training program and designating a competent rated man the responsibility of mantaining the publications section of the work center.

WORKMANSHIP STANDARDS

The main goal of the Navy is to be ready at any given moment to perform any mission assigned. To achieve this goal, all weapons systems must be maintained to the maximum extent possible to perform 100 percent of the functions for which they were designed.

Nonavailability of aircraft due to material deficiencies and poor workmanship are major problems. Therefore, good workmanship standards are necessary to pinpoint troubles before they have a chance to cause serious difficulty. A system that includes inspectors who are skilled in the ADJ rating and trained in good workmanship standards is a vital necessity. This system should include compiling records and information from various sources to gain information on where the greatest difficulty lies and why it is there. The final function of this system is to analyze these facts and point them out to others. It is difficult to find a yardstick to measure the degree of dependability attained. One of the best indications readily at hand is aircraft availability.

PROCURING AND CUSTODY OF MATERIAL

The supervisor is responsible for ordering aircraft maintenance spare parts and material, tools, and other equipment necessary for the accomplishment of assigned maintenance tasks. Necessarily related to this responsibility are requirements for controlling the use of consumable materials, maintaining and accounting for tools and material held on a custody signature basis, and, when required, the preparation and submission of evaluation reports.

AIRCRAFT PARTS

Aircraft parts are generally ordered for two reasons, the first being replacement for parts which are removed from service on a scheduled basis. These are usually parts which by their

failure may cause disastrous consequences. The other general need for aircraft parts results from failure, damage, or unsatisfactory operation of an aircraft component. As can be seen, parts in the former category may be ordered in advance so they can be on hand when required, but the latter category may not, as their usage is generally unforeseen. In either event, the ordering procedure is the same.

NOTE: Prior to ordering a replacement for a failed part, the supervisor should always consider his responsibility and capability to effect the repair of the old part. If this capability exists (and is permissible) at his level and the repair is accomplished, it will prevent the expenditure of a great amount of time, trouble, and money required to process such material through higher levels of maintenance.

The first step in ordering is the identification of the desired part. After the item is identified, the supervisor must contact maintenance control and have a priority assigned the needed part. The supervisor will then notify material control of the item needed, the priority assigned, and the delivery point. Material control does not prepare supply documents for material required in direct support of weapons system maintenance. (Normally, material is considered to be required in direct support of weapons system maintenance when the material is to be utilized in completing a maintenance action which has been assigned a Production or Job Control Number.) Such documents are prepared by the Supply Support Center. Material control verbally notifies the supply organization of the need for such material. The local supply organization is responsible for the physical delivery of RFI material to the maintenance organization and pick-up of the defective material.

In a more or less predictable length of time, consistent with the priority, the part will be delivered to the shop. Prior to opening the package or breaking the preservation in any manner, The Federal Stock Number and any other identifying data on the package should be double checked against the shop order file to insure that they match. Upon depackaging, another check similar to the foregoing should be made to positively identify the part.

If either inspection reveals any inconsistencies of identification data, it may be that the supply office has substituted an interchangeable item. If so, the substitute item should be checked in the Illustrated Parts Breakdown, Section B Allowance List, or the Interchangeable List for ASO and NavAir Cognizance Repairable Assemblies. If possible, an actual comparison with the old part should be made prior to installation as a further check for suitability.

TOOLS

Ordering of tools is accomplished in much the same manner as in the past. After the tool is identified, a filled-in, rough copy of the requisition form is forwarded to material control or unit supply office. This form may be either a DD 1348, or a locally issued form which provides spaces for the required information. In the material control office or supply office, a smooth copy is prepared, the necessary accounting data added, signed, and forwarded to the main supply activity.

The need for a tool should develop during a periodic tool inventory, when all tools should be cleaned and inspected, and repaired or replaced as necessary.

Unlike aircraft parts, which should be stocked in the work center, the section G allowance Lists provide for each Organizational maintenance activity to have on hand a certain quantity of tools. The applicable allowance lists should be cross checked with a current tool inventory and any deficiencies made up as soon as possible. In some cases, it may be determined that some tools on the allowance lists are not needed or that the allowed quantity exceeds actual requirements. In such cases, those tools should not be ordered just to have them collect dust on the toolroom shelves. In addition, excess tools serve to complicate the periodic inventories as well as posing a transportation problem when the squadron deploys.

GROUND SUPPORT EQUIPMENT

Items of ground support equipment (GSE) used for servicing and maintaining aeronautical equipment consists of equipment furnished as organizational property and equipment furnished on subcustody from the supporting activity. The Individual Material Readiness List (IMRL) discussed in chapter 2 of this manual provides an authorized allowance listing for GSE which may be procured or obtained on subcustody by the supported activity.

Work centers charged with the custody of GSE must insure that proper care is exercised in its daily maintenance, upkeep, and operation. Preoperational/or Daily Maintenance Requirements Cards are available for use in maintaining

most larger items of support equipment. Items on subcustody from the supporting activity are normally recalled to the supporting AIMD for periodic maintenance inspections.

The supporting activity licenses qualified operators and provides GSE training, in addition to that which may be given as part of the work center's training syllabus. All operators of ground support equipment must be qualified and licensed. The license should be carried at all times when operating GSE.

Status code A ground support equipment is that equipment in the possession of an Organizational or Intermediate maintenance activity and being used in support of assigned missions. Reporting custodians are accountable for each item of GSE in status code A and must report data on its utilization (hours/cycles/starts). Prepunched/preprinted GSE cards are available for utilization reporting. Utilization is reported on the last day of each reporting period.

GSE on subcustody to squadrons or other activities remains the responsibility of the reporting custodians. Personnel designated as being responsible for GSE, within the activity having subcustody, must compile utilization on the appropriate GSE card and forward it to the reporting custodian on the last day of the reporting period. Reporting procedures are provided in detail in volume III of the Naval Aviation Maintenance Program, OpNav 4790.2 (Series).

INVENTORY AND RECORDS

When the shop is first set up and the initial allowance of tools and equipment is drawn, inventory cards should be made up on each item. These cards should include the name of the item, quantity, manufacturer, model, stock number, date of acquisition, cost, and dates and nature of repairs and replacement parts.

Some items should be kept in the work center toolroom or special cabinet; others placed in individual toolboxes and issued to the workers. A toolbox inventory record should be prepared in duplicate with the original filed in the work center files and the duplicate copy placed in the toolbox, preferably in an oil and grease resistant envelope.

While each toolbox should be adequately stocked, it should not contain tools in excess of actual requirements. Maintenance personnel must utilize some method of tool accountability following each maintenance action to prevent tools being left adrift. Tools should be etched or marked in some manner that will identify them to a specific work center and toolbox. This acts as a deterent to leaving tools adrift and provides the additional benefit of cutting down on the amount of tool pilferage.

A monthly inventory should be conducted beginning with the toolboxes and ending with the toolroom count. The periodic inventory should be more than just an item count. Since each item is sighted, it provides an opportunity to ascertain if the tools in actual use are being maintained in good repair. If they show evidence of damage or improper use, appropriate corrective action should be taken. The men should be encouraged to make good use of delay time by tool maintenance and equipment servicing.

Aircraft Inventory

In the past, there has always been a problem in maintaining custodial control and location information on command-controlled aeronautical components and aircraft related equipments. In order to maintain an unbroken chain of custodial responsibility incident to the transfer and acceptance of naval aircraft, the Standard Inventory Log was developed by the Navy to be used as an instrument of transfer. In the interest of standardization among the armed services, the Aircraft Inventory Record has been designed by the Department of Defense for this purpose. Records (instead of Logs) are now being prepared by the Navy for new production aircraft and when old Logs are revised.

With remote exceptions, no aircraft may now be transferred or accepted without an Inventory Log or Record. On these occasions, an inventory of the aircraft and its equipment must be accomplished, based on the items of equipment and material contained in the applicable Log or Record.

Although the Log and Record serve the same purpose, there are some minor differences in their format and categorical listings. In general, the determination as to whether items are, or are not, subject to listing in these publications without regard as to whether they are contractor or government furnished and contractor or service installed, is governed by the following:

1. Items essential to the execution of the designated missions of the aircraft, such as armament, electronics, photographic equipment (excluding cameras other than for primary missions), and special instruments, are included.

2. Items of equipment which are rigidly fixed and considered to be a basic or integral part of the airframe, such as engines, propellers, wheels, tires, and brakes, are excluded. In the case of the Aircraft Inventory Record, standard instruments are also excluded.

3. Special equipment items essential to the safety or comfort of the crew such as bedding, liferafts, Thermos bottles, crash axes, and portable fire extinguishers are included. Comparable items which are personal issue or furnished on squadron allowances are excluded.

4. Loose equipment delivered with the aircraft, such as covers, mooring kits, and jack pads, for which stowage provisions have been incorporated in the aircraft, are included.

5. Items subject to pilferage or readily convertible to personal use, such as clocks, Thermos jugs, bedding, and first aid kits, are included. Comparable items which are personal issue or furnished on squadron allowances are excluded.

The Standard Inventory Log is subdivided into groups of equipment (e.g., instrument and navigation equipment, armament equipment, and electronic equipment). The components are listed in alphabetical sequence and according to their location in the aircraft, with the exception of the electronics equipment, in which case all components of an equipment are listed in one place regardless of their location in the aircraft. Stock numbers are also supplied for individual items, and are used for ready reference when replacements are required.

The Aircraft Inventory Record includes a sectional breakdown diagram of the applicable aircraft. This diagram consists of a side elevation and/or the plan view of a wing, or in the case of twinboomed or flying wing aircraft, the perspective view.

To facilitate inventorying, the sections of the diagram are identified by letters, the letter "A" being assigned to the foremost section, "B" to the next, and so on, generally to the rear of the aircraft. The letter "R" as part of the item number, denotes items mounted on the exterior of the fuselage, and the letter "F" denotes items to which access is gained from the fuselage. Subdivisions of sections may be identified by a lower case letter such as "Aa" "Ac" etc.

The equipment list portion of the Record is divided into sections, each of which lists the items pertaining to a particular section of the aircraft, as indicated on the sectional breakdown diagram. Within each section, individual items are numbered as nearly as possible in the sequence of thier physical location in the aircraft without regard to their relation to specific equipment. Stock numbers are not supplied as part of the equipment listing in Inventory Records.

One Standard Inventory Log in general is issued as applicable to one aircraft model and designates material and equipment peculiar among the various applicable versions and bureau numbers. The Aircraft Inventory Record is issued as applicable to one aircraft for a specific bureau number.

Blank columns are provided on the inventory pages of the Log and Record, in order that transferring and receiving activities may jointly inventory and indicate the quantity of each item ascertained to be on board the aircraft at the time of transfer. A RECEIPT ENDORSEMENT LOG in the Standard Inventory Log, and a CERTIFICATE AND RECORD OF TRANSFER in the Aircraft Inventory Record are provided so that transferring and receiving activities may sign, indicating by column applicability, the items on board the aircraft.

Upon the transfer of an aircraft, representatives from the transferring and receiving activities jointly inventory and record, in the appropriate column, the quantity of each item which is ascertained to be on board the aircraft at the time of transfer. When a ferry pilot, or a naval vessel is involved in the transfer, two inventories are made, one prior to the ferry flight or embarkation, and one upon completion. In the former instance the ferry pilot or vessel is considered to be the receiving activity, and in the latter instance the transferring activity.

A Report of Inventory Form supplied with the Standard Inventory Log, or the Shortages Form (DD780-2) in the Aircraft Inventory Record, is generally prepared in triplicate, listing missing items with appropriate remarks. The original is retained by the transferring activity and is filed as a permanent record of transfer.

The first carbon copy of the form is left in the Standard Inventory Log or Aircraft Inventory Record, as the case may be, and is delivered along with the Log or Record to the activity receiving the aircraft.

The second carbon copy of the report or shortages form is forwarded to the cognizant major operating command (controlling custodian) of the transferring activity for information and any appropriate action deemed necessary.

In the case of missing items, the transferring activity makes every effort to locate the missing items or to withdraw from store the replacement items necessary to complete the inventory. If it is impossible to locate or supply the missing items, the notation "Missing items are not available" is placed in the Report of Inventory Form in the Standard Inventory Log or the Shortages Form in the Aircraft Inventory Record. An explanatory statement signed by the transferring representative is placed with this form, indicating the authority for these shortages. On the basis of this statement, the receiving activity may fill the shortages from stock and account for them in the normal manner.

When the aircraft is abandoned or disposed of by scrapping, the Inventory Log or Record may be destroyed by the activity disposing of the aircraft. When the aircraft is transferred to other U.S. agencies, the Log or Record is also transferred. When the aircraft is sold to a private party, the Inventory Log or Record is forwarded to the Naval Air Systems Command immediately after consummation of the sale and include the signatures of the last custodian (seller) and the purchaser. In order to provide the buyer with inventory information, the Log or Record may be duplicated, provided that it includes no classified information.

Aeronautical Equipment Service Record (AESR)

The AESR is prescribed for use as a service record for aircraft powerplants, auxiliary power units (airborne), airborne gun pods, low-level escape systems, propellers, in-flight refueling stores/packages, quick engine change kits, and gas turbine compressor engines (ground).

The aircraft logbook is a hard-cover, loose-leaf ring binder containing separators and page insert forms.

The AESR is initiated by the activity accepting the equipment from the Navy, and is subsequently maintained by the activity having custody of the equipment at all times. When equipment is installed as part of the aircraft, this record is maintained concurrently with and becomes part of the Aircraft Logbook.

The AESR is maintained similarly to the Aircraft Logbook. Since it is in loose-leaf form, the full identification data and serial number are inserted on each page to insure ready identification when pages are removed for entries or for any other reason.

The following forms make up the complete AESR:

- Custody and Transfer Form.
- Equipment Operating Log.
- Inspection Record Form.
- Record of Rework Form.
- Technical Directives Form.
- Miscellaneous/History Form.
- Scheduled Removal Components Form.
- Scheduled Removal Component Card.

Supplemental forms include the following:

- Turbine Rotor Disc Assembly Record.
- Afterburner Service Record.
- Compressor Rotor Assembly Service Record.

For detailed information on these forms as well as other Aircraft Logbook forms and records, reference should be made to chapter 6 in volume II of OpNav 4790.2 (Series).

COST CONSCIOUSNESS

The Navy Cost Reduction Program, NavSo P2486, strives to create an attitude of total cost consciousness and to encourage the development and implementation of cost reducing actions. Maintenance supervisors as well as their subordinates can play a definite role in reducing costs. Areas where costs can be reduced should be identified and action taken through the chain of command. Recognition to the individual responsible for any cost reduction actions will serve to stimulate the cost reduction program.

Personnel involved in procurement of material and equipment and those charged with custody of such items should realize that the overall cost for defense material is tremendous. Costs of weapons systems, associated test equipment/support equipment, and spare parts necessary to support the weapon system during its expected service life have increased steadily to the point where improved management is necessary. Attention must be given resources, utilization of personnel, accident prevention, etc.

Improved work habits, elimination of unnecessary maintenance tasks, improvements to test equipment, consolidation of functions, greater use of resources, and increased capability for repair of specific items at the lowest level of maintenance are but a few areas that could be evaluated as a means of reducing costs at the working level. Supervisors should be alert to ways of bringing about such improvements and should encourage and assist their personnel in submitting factual beneficial suggestions for consideration and subsequent dissemination.

Materials belonging to the Navy are not procured for personal use of the individual, yet thousands of dollars are lost annually due to poor control of material resources. Proper security of pilferable items will materially reduce costs. Ordering only that material which is actually needed rather than that which "might" be needed is another area that generally could receive attention. The ways of reducing costs are limited only by the supervisor's imagination and ingenuity. Waste, whether it is of manpower, money, or material, costs the taxpayer and therefore affects almost everyone.

EVALUATION REPORTS

The maintenance of today's high-performance aircraft requires more and more special tools, shop equipment, and ground-handling equipment. Most of this special equipment is designed and manufactured by private contractors. The manufacturers frequently request individual fleet activities to conduct performance evaluations on items which have been purchased by the Navy and are new to the industry. This practice is approved and encouraged, but a standard procedure for conducting performance evaluations is necessary.

According to current instructions, the manufacturer's request must be approved by the cognizant COMFAIR before it can be accepted by the fleet activity requested to perform the evaluation. Upon approval, the activity conducting the evaluation will provide the manufacturer, via the COMFAIR, with a report of the evaluation findings, citing any defects or recommendations for improvement. The report should include the manufacturer's name, name of product, model number, size, and/or capacity of the product evaluated, and the specific function for which the product may have been used.

TECHNICAL PUBLICATIONS

Aeronautical publications are the sources of information for guiding naval personnel in the operation and maintenance of all aircraft and related equipment within the Naval Establishment. By proper use of these publications, all aircraft and other aeronautical equipment can be operated and maintained efficiently and uniformly throughout the Navy.

General information pertaining to the major publications of interest to naval aviation maintenance personnel is contained in Aviation Machinist's Mate J 3 & 2, chapter 2, NavPers 10341-B, and knowledge of the material in that text is presumed.

TECHNICAL DIRECTIVES

The Technical Directive System has been established for the control and issue of all technical directives. This system standardizes the method of issuance for such directives and is the authorized means for directing the accomplishment and recording of modifications and one-time inspections of ground support equipment as well as aircraft and other aeronautical equipment. The Technical Directive system is an important element in the programs designed to maintain equipment in a safe and current state of operational and material readiness.

This system provides for two types of technical directives. The types are determined by the method of dissemination. The two types are Formal (letter type) and Interim (message type). In general terms, they are both considered as letter type publications. Such directives contain instructions or information of a technical nature which cannot be disseminated by revisions or changes to technical manuals. However, the accomplishment of a technical directive often necessitates a change or revision to the applicable technical manual. Technical directives are issued in the form of Changes, or in the case of special circumstances, by Interim Changes or Interim Bulletins.

A formal technical directive is issued as a Change, or as an amendment or revision thereto, and, as stated previously, is disseminated by letter. Formal directives are used to direct the accomplishment and recording of modifications to support equipment, as well as aircraft and related equipment. An interim technical directive is issued as a Change or a Bulletin, or as an amendment or revision thereto, and, in order to insure prompt delivery to the concerned activities, is disseminated by message. The interim technical directive is reserved for those instances to correct a safety or operational condition whenever it is considered too important to risk waiting for the issuance of a formal directive.

Each interim Change is superseded by a Formal Change directive which will have the same number as the interim directive. Interim Bulletins are not superseded by formal Bulletins as was previously the case. NavSup Publication 2002, Section VIII, Part D will still have many

formal Bulletins listed until they are eventually phased out.

A Change is a document containing instructions and information which directs the accomplishment and recording of a material change, a repositioning, a modification, or an alteration in the characteristics of the equipment to which it applies. A Change is issued to direct that parts be added, removed, or changed from the existing configuration or that parts or material be altered, relocated, or repositioned.

A Change may be issued in parts to accomplish distinct parts of a total directed action or to accomplish action on different configurations of affected equipment.

A Bulletin is an interim document comprised of instructions and information which directs an initial inspection to determine whether a given condition exists. It specifies what action is to be taken if a given condition is found or not found.

Sometimes it is found that a Change or Bulletin is not the complete answer to a problem, and it is determined necessary to amend or revise an outstanding directive. An Amendment is a document comprised of information which clarifies, corrects, adds to, deletes from, makes minor changes in requirements to, or cancels an existing directive. It is only a supplement to the existing directive and not a complete directive in itself. A maximum of three Amendments may be applied to any technical directive, each remaining in effect until rescinded or superseded by a Revision. A requirement for further amendment action necessitates the issuance of a Revision.

A Revision is a completely new edition of an existing technical directive. It supersedes the original directive and all existing Amendments.

Interim Bulletins are self-rescinding with rescission dates of 30 June and 31 December, whichever is appropriate for the case at hand. Rescission is the process by which a technical directive is removed from active files after all requirements have been incorporated and recorded. Rescinding dates are also projected for formal changes. Final rescission action of all technical directives is directed in Part D, Section VIII, NavSup Publication 2002. All activities maintaining files of technical directives should retain all technical directives until they are deleted from NavSup Publication 2002.

Changes and Bulletins are issued by technical personnel of the Naval Air Systems Command and are based on Contractor Service Bulletins, on reports from various Data Services, or letters of recommendation or proposed modifications from field service activities. They are automatically distributed to all activities concerned through inclusion on the Mailing List Request for Aeronautic Publications, NavAir 5605/3.

Changes and Interim Changes are assigned numbers in a numerical sequence by the Technical Directives Control Center, located at the Naval Air Technical Services Facility (NATSF), Philadelphia, Pa. As stated previously, a Formal Change which supersedes an Interim Change will have the same number as the Interim Change. Interim Bulletins are numbered similarly in another number series.

The title of a Change or Bulletin for support equipment is made up of three parts. Part one is the term "Support Equipment;" part two, the word or words "Change," "Interim Change," or "Interim Bulletin;" and part three, the sequential number. When applicable, the words "Rev. A," "Amendment 1," etc. follow the basic directive.

Changes are classified by various "action" categories. Bulletins may also be assigned an action classification, but it is not mandatory. The assigned action category serves as a priority for compliance with the various directives.

The category "Immediate Action" is assigned to directives which are issued to correct safety conditions, the uncorrected existence of which would probably result in fatal or serious injury to personnel, extensive damage, or destruction of property. Immediate Action directives involve the discontinued use of the equipment in the operational employment under which the adverse safety condition exists, until the directive has been complied with. If the use of the equipment will not involve the use of the affected component or system in either normal or emergency situations, compliance may be deferred, but should be accomplished no later than 120 days from the date of issue. Immediate Action directives are identified by a border of red X's, broken at the top center of the page by the words "IMMEDIATE ACTION," also printed in red.

The category "Urgent Action" is assigned to directives which are used to correct safety conditions which, if uncorrected, could result in personnel injury or property damage. This category of directive is identified by the words "URGENT ACTION" printed in red ink at the top of the first page and a border of red diagonals around the cover page.

The compliance requirements for Urgent Action directives specify that the incorporation of the instructions must be accomplished not later than the next regularly scheduled rework or overhaul or, for equipment not reworked or overhauled, on a regularly scheduled basis, not later than 18 months after the date of issuance.

Routine Action directives are issued where there are reliability, capability, or maintainability deficiencies which could, if uncorrected, become a hazard through prolonged usage or have an adverse effect on the operational life or general service utilization of equipment. The compliance requirement specifies the incorporation of the instructions not later than the next regularly scheduled overhaul or rework, or for equipment not reworked or overhauled on a scheduled basis, not later than 18 months after issuance of the directive. If accomplishment of the work requires Depot level maintenance capability, the compliance may be deferred if it will seriously interfere with operational commitments or schedules. Routine Action directives are identified by the words "ROUTINE ACTION" printed in black capital letters at the top center of the cover page.

Record Purpose category is assigned to a technical directive when a modification has been completely incorporated by the contractor before acceptance by the Navy. This category of technical directive merely documents the action for configuration management purposes. Consequently, compliance information is not applicable. They are identified by the words "RECORD PURPOSES" printed in black capital letters at the top center of the cover page.

INSTRUCTIONS AND NOTICES

Instructions and Notices are the two main types of directives provided for in the Navy Directives System which was designed for the purpose of providing a uniform plan of issuing and maintaining directives. Directives may establish policy, organization, methods, or procedures. They may require action to be taken or contain information affecting operations or administration. All Naval Air Systems Command level (and above) originated directives are distributed by the Navy Department Administrations Office, with certain exceptions. Each level of command below Naval Air Systems Command level has an administration office responsible for distributing that level of command directives to its units or addressees below them.

Instructions and Notices are identified by originator and subject classification. A typical directive identification breakdown follows:

OpNav Instruction 3750.1A. OpNav indicates that this instruction originated in the office of the Chief of Naval Operations. The 4-digit number 3750 is the subject classification number. This particular number indicates the series on Flight Safety. The number 1 indicates the number of issues the originating office has issued on this subject. (Notices do not have this number.) The letter A indicates the number of times this Instruction has been revised; i.e., A for first revision, B for second, etc. If the letters C or S precedes the subject classification number, it indicates the classification of the subject. The letter C indicates confidential and S indicates secret.

There are 13 major subject classification number groups, ranging from the 1000 group to the 13000 group. The 13000 group is set aside for aeronautical and astronautical material.

MAINTENANCE INSTRUCTIONS

The Maintenance Instruction Form OpNav 4790/35 is usually prepared by the cognizant division; however, it may be drafted by a division designated by the Maintenance Officer. These forms have been provided for the use of maintenance departments as the standard form for the interpretation and/or amplification of technical directives and maintenance requirements received from higher authority. The forms may also be used to issue local technical instructions.

A review of the draft should be conducted by the Quality Assurance Division as well as the maintenance/material coordinator prior to the approval by the Maintenance Officer. The Maintenance Instruction must be prepared carefully, because it is the instrument the division officer uses to direct his men. Command directives in the form of messages are often so brief, that to be understandable at the working level they need considerable amplification and background information. On the other hand, lengthy and detailed directives prepared for all aviation activities may be received. Only parts of these directives may be applicable locally, and the directives need condensation and selection to adapt them to local conditions. The three purposes that a Maintenance Instruction may be used for are as follows:

1. A SAMI (Single Action Maintenance Instruction) may be prepared when a directive or

situation dictates that specific work must be performed on a one-time basis. By their nature, SAMI's have a limited period of applicability, and positive action must be taken to cancel SAMI's which have served their purpose.

2. A CAMI (Continuing Action Maintenance Instruction) may be prepared when a directive or situation dictates that specific work must be performed at recurring intervals contingent upon elapsed time or upon the occurence of a particular condition or incident. When the work ordered may be performed on an aircraft or piece of equipment at recurring intervals, it is properly the subject of a CAMI. It is important that it be clearly stated when the prescribed action is taken and that positive control be exercised to insure that the work is actually performed. If the aircraft model concerned is maintained under the calendar inspection system, using MRC's (Maintenance Requirements Cards), any new maintenance inspection requirements should be considered for inclusion in the MRC deck rather than as CAMI material. A copy of these requirements, generated by other than CNO and NavAirSysCom, with reference, should be submitted with an Unsatisfactory Material/Condition Report (OpNav Form 4790/47) to be considered for inclusion in the next revision to the MRC's.

3. A TIMI (Technical Information Maintenance Instruction) may be prepared when a directive or situation dictates that technical information must be promulgated within the activity. When it is necessary to disseminate information, such as techniques and local policy, which does not direct the performance of specific work at intervals, but which is sustaining in nature, a TIMI may be properly issued; e.g., information on hydraulic fluid contamination.

MANUAL PUBLICATIONS

To attain a satisfactory state of readiness, technical manuals are developed, published, and distributed concurrently with the weapon system or equipment that they cover. Periodic changes and revisions are issued as necessary to insure that manuals continually reflect equipment changes and current operational and support concepts and procedures. Technical manuals released under the authority of the Commander, Naval Air Systems Command, are considered the only authorized source of the information provided, and the instructions they contain are mandatory.

The variety of manual publications available to the AD are designed to provide all essential information necessary to understand the operational theory, troubleshoot and service the system, and maintain the weapon system and/or its associated components.

General Manuals (00 Series)

As indicated by the title, this series of manuals includes information of interest to all naval aviation personnel. In the final analysis, some publications in this series may not be considered as actual technical manuals; however, they furnish aircraft maintenance activities with valuable required information. Manuals included in the general (00) series that are of interest to the AD are the four parts of the Naval Aeronautical Publications Index (00-500A, 00-500B, 00-500C, and 00-500D), Initial Outfitting Lists and Allowance Lists, and the Aviation Training Literature.

Aircraft Manuals (01 Series)

The following types of manuals are prepared and issued for each model of aircraft used by the Navy:

NATOPS (Naval Air Training and Operating Procedures Standardization Program) Flight Manual, herein referred to as Flight Manual.

Maintenance Instructions Manual.

Structural Repair Manual.

Illustrated Parts Breakdown.

Periodic Maintenance Requirements Manual, including related Maintenance Requirements Cards and Sequence Control Charts.

NOTE: The Periodic Maintenance Requirements Manual (PMRM) is being replaced by Periodic Maintenance Information Cards.

The NavAirSysCom also provides a series of General Engineering Manuals, applicable to all aircraft models, and available to aircraft maintenance activities. These publications are concerned with such subjects as Corrosion Control, Aircraft Structural Repair, Aircraft Hardware, and Aircraft Cleaning. As previously stated, these publications are of a general nature and are used in conjunction with the specific aircraft model manuals. These general manuals are grouped at the beginning of the 01 series manual listing in NavSup 2002, Section VIII, Part C.

A maintenance Planning Manual is issued (for newer models) to serve as the maintenance officer's source of information on maintenance management with respect to the particular

weapons system. It contains information on what the total maintenance plan for the weapons system is, what facilities, equipment, material, space, and personnel will be needed, and what resources, including technical information, services, training, supply support, etc., are available and how to obtain them.

FLIGHT MANUAL.—The Flight Manual contains complete operating instructions for the aircraft and its operational equipment. Emergency operating instructions as well as normal operating instructions are provided. Although Flight Manuals are issued primarily for the use of pilots and aircrewmen, they provide valuable operational information to maintenance personnel as well.

Two methods of updating Flight Manuals are by regular change notices and by interim manual changes. Regular change notices are issued periodically and cover routine changes and instructions. Interim manual changes cover vital operating instructions and are issued when immediate action is necessary.

Flight Manuals for newer aircraft models are identified by -1 in Part III of the publication code. For example, NA 01-40 AVC-1 identifies a Flight Manual for the A-4E.

MAINTENANCE INSTRUCTIONS MANUAL. —The Maintenance Instructions Manual (MIM) contains most of the essential information required by aircraft maintenance personnel for service and maintenance of the complete aircraft. It includes the data necessary for troubleshooting and maintaining the powerplant, accessories, and all systems and components of the aircraft.

Instructions in the Maintenance Instructions Manual include such typical service and maintenance operations as the following:

1. Routine servicing.
2. Lubrication requirements.
3. Cleaning.
4. Adjustments.
5. Minor repairs.
6. Removal and replacement of components.
7. Testing.

The Maintenance Instructions Manual for all current production aircraft is made up in volumes, each volume being individually bound and issued separately. This permits each work center in an activity to have its own applicable volume, or volumes at hand for ready reference.

Classified maintenance information is not included in the regular volumes of the Maintenance Instructions Manual. Essential classified information is contained in separate volumes or supplements of the Maintenance Instructions Manual which are classified "confidential." These volumes are usually bound in red in order that they may be readily identified and should be handled in accordance with the Department of the Navy Security Manual for Classified Information.

The various volumes of the Maintenance Instructions Manual cover such areas as the following:

General Information and Servicing.
Airframe Group.
Powerplant and Related Systems.
Armament and Photographic Systems.
Electrical Systems.
Communication and Radio Navigation Systems.

The first volume, usually titled General Information and Servicing, is designated primarily for the plane captain; however, this volume contains a great deal of information important to all maintenance personnel. It contains a general description of the aircraft, all information pertaining to servicing the aircraft, and necessary information which is not contained in other specialized volumes.

Each of the specialized system volumes (airframe, powerplants, electrical, etc.) of the Maintenance Instructions Manual is further divided into four sections, as described in the following paragraphs.

Section I is the same in all volumes of a particular aircraft Maintenance Instructions Manual. This section provides an introduction to the manual and usually supplies a list of the changes applicable to the particular volume concerned.

Section II describes the system and components as well as their operation.

Section III provides such maintenance coverage as removal and installation procedures and troubleshooting charts for the Organizational level of maintenance.

Section IV provides component repair procedures for the Intermediate level of maintenance.

The different aircraft manufacturers may group the material in the various volumes of the Maintenance Instructions Manual under different titles. For example, the Survival and Environmental Systems MIM for one model aircraft may be contained in one volume; whereas, another model aircraft may have two or more volumes to cover the same subjects.

As previously stated, the complete MIM for an aircraft consists of several separately bound volumes. Each volume is assigned an individual publication code number for identification purposes. The complete MIM is divided into groups of volumes (categories) containing related data or related systems.

Maintenance Instructions Manuals are identified by -2 in Part III of the publication code. Additional dash numbers are used to identify the different groups or categories. Point numbers are used to identify subsystems or related data to these groups or categories. For example, NA 01-75PAA-2-4 is the code number for the P-3A MIM for the Powerplant and Related Systems. NA 01-75PAA-2-4.1 signifies the MIM for Powerplant Buildup for the P-3A.

STRUCTURAL REPAIR MANUAL.—This manual is prepared primarily for personnel of the AM rating and is used as a guide in making structural repairs to the airframe. It contains general information such as airframe sealing, control surface rebalancing, general shop practices, damage evaluation and support of structure, and a description of the structure through the medium of indexed illustrations and repair drawings.

The Structural Repair Manual for most new aircraft is published in two volumes. This is not due to its size but is to suit its usage by different facilities. Volume I is for use at all levels of maintenance. Volume II supplements volume I and contains information used only at Depot level facilities.

ILLUSTRATED PARTS BREAKDOWN.—This is actually a parts catalog which lists all the parts of the complete aircraft. The purpose of the Illustrated Parts Breakdown (IPB) is to assist supply, maintenance, and overhaul personnel in the identification, requisitioning, storing, and issuing of parts for the applicable aircraft.

The Illustrated Parts Breakdown for older aircraft, like the Maintenance Instructions Manual, may be found in one volume. The Illustrated Parts Breakdown prepared for current production aircraft contains several volumes which usually correspond to the volumes in the Maintenance Instructions Manual.

A - 4 in Part III of the publication code identifies the Illustrated Parts Breakdown. The individual volumes are identified by an additional dash and number. An example of the code number for an Illustrated Parts Breakdown in current use is NA 01-75PAA-4-5. This is the code number for the Powerplant and Related Systems volume of the P-3A IPB.

Each volume of the Illustrated Parts Breakdown is divided into at least two sections and sometimes three—section I, Introduction; section II, Group Assembly Parts List; and section III, when used, Numerical Index. Section I contains detailed instructions for the use of the Illustrated Parts Breakdown. Section II includes illustrations of all parts of the applicable aircraft and its systems, equipment, and special support equipment subject to separate maintenance.

The latest type Illustrated Parts Breakdown has a separate volume for the Numerical Index. The Numerical Index contains an alphanumeric listing of all parts in the Illustrated Parts Breakdown or volume. In addition to part numbers, the Numerical Index contains figure and index numbers and source code data.

Study of the Introduction (section I) will provide all the necessary information required to properly use the Illustrated Parts Breakdown.

PERIODIC MAINTENANCE REQUIREMENTS MANUAL.—This manual contains the planned scheduled maintenance requirements for the particular aircraft concerned and is the controlling document for the planning and accomplishment of related work tasks through all levels of maintenance. The maintenance requirements it contains are set forth in a manner that specifies the equipment to be inspected or examined and the conditions to be sought in each instance. The Periodic Maintenance Requirements Manual (PMRM) does not contain instructions for repair, adjustment, or other means of rectifying defective conditions, nor does it contain instructions for troubleshooting to determine causes of malfunctions.

The requirements prescribed in the Periodic Maintenance Requirements Manual are considered to be the minimum necessary under any condition to assure timely discovery and correction of latent defects and compliance is mandatory. Due to varying operational requirements, climatic or environmental conditions, cognizant commanders may increase the scope or frequency of inspections or examinations as required to properly and safely support operations.

Like most technical manuals, the Periodic Maintenance Requirements Manual is divided into parts or sections. These parts/sections cover such areas as Fleet Maintenance Requirement, Progressive Aircraft Rework Requirements, Component Removal/Replacement

Schedule, Accessory Record Card Requirements, and Functional Test Flight Requirements.

The Periodic Maintenance Requirements Manual is updated by periodic change notices and revisions. This manual is identified by a -6 in Part III of the publication code. An example of a code number for the P-3A Periodic Maintenance Requirements Manual is NA 01-75PAA-6.

NOTE: The PMRM's are scheduled to be replaced by Periodic Maintenance Information Cards, thus eliminating manual changes whenever a change in maintenance requirements occurs.

Aircraft Components and Related Equipment Manuals

These manuals are not limited to but include Accessories Manuals, Instrument Manuals, Armament Manuals, and Electronics Manuals. The 03 series manuals cover all types of accessories; Instrument Manuals are covered in the 05 series; the 11 series manuals are concerned with Armament and related equipment; and the 08 and 16 series pertain to Electronics Manuals.

The manufacturer of each item of equipment (carburetor, altimeter, bomb rack, radar set, etc.) is required to provide adequate instructions for operating the item and maintaining it throughout its service life. These manuals therefore contain descriptive data; detailed instructions for installation, operation, inspection, maintenance, and overhaul; and an illustrated parts list. All manuals pertaining to these different items of equipment available for issue are listed in numerical order (by publications number) in the applicable section of Part C, Section VIII of NavSup Publication 2002. They are also listed in 00-500A, but in alphanumeric order according to model, type, or part number. In 00-500B, these manuals are listed under the aircraft in which the item is installed.

Aircraft components and related equipment manuals are used to supplement information found in the aircraft Maintenance Instructions Manual. For example, when the Maintenance Instructions Manual does not give instructions for repairing a particular item, reference should be made to the applicable item manuals.

If a component or piece of equipment is relatively simple, all the necessary instructions may be contained in a single manual. More complex items may require two or more manuals. For example, one manual may cover operation, service, and overhaul instructions, while the parts breakdown is contained in a separate manual.

Support Equipment Manuals (17 and 19 Series)

The 17 and 19 series of technical manuals cover most types of support equipment. The manufacturer of each item of support equipment is required to furnish adequate instructions for operating the equipment and maintaining it throughout its service life. Like aircraft Maintenance Instructions Manuals, these publications, prepared by the manufacturer, are issued under the authority of the NavAirSysCom and are then official Navy publications.

Support Equipment Manuals are stocked, cataloged listed, and located in the same manner as aircraft components and related equipment manuals.

Included in the 17 and 19 series of technical manuals are the Maintenance Requirements Cards for various ground support equipment.

Descriptive Data Sheets for Aviation Support Equipment (20 Series)

These sheets provide a consolidated source of descriptive information about individual items of aviation support equipment not available elsewhere.

The type of data furnished on these sheets includes the following:

Official nomenclature of the item.
Manufacturer and model/type number.
Functional classification.
Federal Stock Number.
A photograph or drawing of the item.
Functional description (purpose).
Reference data and literature available about the item.
Shipping data (size, weight, etc.)

NOTE: At the time of this writing, the 20 Series Descriptive Data Sheets are being superseded by MIL-HDBK-300B, Military Standardization Handbook, Technical Information File of Ground Support Equipment. This handbook, which contains several volumes, provides descriptive information similar to that listed for Descriptive Data Sheets. However, it includes ground support equipment used by the Air Force, Army, and Navy.

PROCUREMENT OF PUBLICATIONS

The Navy has available publications that are specifically prepared to assist maintenance personnel; however, either through lack of knowledge of their existence or the procedure for obtaining them, the mechanic is often deprived of the benefits they are intended to provide.

There are four main methods of procuring publications relating to naval aircraft maintenance.

The first method is initial outfitting. The Forms and Publications Supply Office of the Naval Supply Systems Command automatically provides the prospective commanding officer of a newly commissioned or reactivated ship, station, or activity an outfitting of general aeronautic publications.

Specific publications obtained under an Aero nautic Technical Publication Outfitting Allowance constitute another prime source of publications. Initial distribution is provided by the Naval Air Technical Services Facility to a newly commissioned or reactivated activity. Upon change in mission or aircraft custody which requires a different set of publications, an Aeronautic Technical Publication Outfitting Allowance, applicable to the model designation of the aircraft involved, may be obtained upon commanding officer's letter request to NATSF.

The third source of publications is through inclusion on automatic distribution lists. The NATSF normally provides for the issue of certain future issues of new and revised publications directly to affected activities. Activities desiring to receive future issues of new and revised publications must submit a "Mailing List Request for Aeronautic Publications" to the Commanding Officer, NATSF. Powerplant work center supervisors desiring to receive particular issues, reissues, and revisions of publications should make their requirements known to the maintenance office so that they may be included on the next submission of the mailing list request.

The fourth method of procuring publications is by ordering individual publications direct. The Single Line Item Requisitioning System Document (DD Form 1348 or DD Form 1348M) is used by activities when requisitioning aeronautic publications on a one-time requirement. The use of DD Form 1348 or DD Form 1348M will not result in being placed on the distribution list to receive future issues or revisions of the publication ordered.

Detailed information concerning the availability of aeronautic publications may be found in the Naval Aeronautic Publications Index. The complete index is made up of five parts, as follows:

NavSup 2002, Section VIII, Parts C and D—Numerical Sequence List.

NavAir 00-500A—Equipment Applicability List.

NavAir 00-500B—Aircraft Application List.

NavAir 00-500C—Directives Application List.

NavAir 00-500D—Letter Type Technical Directives—Equipment and Subject Applicability List.

NavSup 2002, Section VIII, Parts C and D, contains a complete numerical listing of all available naval aeronautic publications distributed by NavAirSysCom and stocked for issue as of the date of publication. This numerical listing contains all available publications by publication number, stock number, and title. Publications are subdivided into subject groups according to type of aircraft or equipment, or component thereof.

Part C contains a numerical listing of manual type publications. A table of contents and a general alphabetical cross-reference listing are provided as well as instructions for use of the manual.

Part D is a numerical listing of all letter type publications.

NavAir 00-500A contains an alphanumerical listing of aeronautical equipment by model, type, or part number, and indicates all manuals by their number that are applicable to each item of equipment.

NavAir 00-500B contains a listing of the Naval Air Systems Command technical manuals grouped according to their application to an aircraft. This part of the index does not contain a listing of any letter type publications, and the manuals are listed by publication number only.

NavAir 00-500C contains a listing of the active Naval Air Systems Command technical directives with respect to their applicability to an aircraft. It is arranged by aircraft series, by aircraft configuration, and by Airframes/Aircraft Bulletin and/or Change number.

NavAir 00-500D contains a cross-reference of NavAirSysCom letter type directives. This index is divided into two parts—Part A, Equipment Index and Part B, Subject Index. Part A contains a listing of all active directives (NavAirSysCom) on aircraft components and related equipment by model, type, or part number. Each

number falls in alphanumeric sequence within its cognizant equipment series (accessories, aircrew systems, etc.). Part B contains a listing of all active NavAirSysCom letter type directives by subject. The listing is arranged by prime system, component part of the system, and Airframe Title, Bulletin/Change number.

In addition to the technical publications discussed, situations may arise which require the use of engineering drawings. Engineering drawing reproductions provide all the necessary information to construct, assemble, and install a part or an assembly. The manufacturers provide the NATSF and various Rework Facilities with microfilm and Vandyke copies (blueprints) of engineering drawings. These activities also have microfilm readerprinters for viewing and reproducing these engineering drawings required in maintenance tasks.

SECURITY OF CLASSIFIED PUBLICATIONS

The problem of security of classified publications in the work center files is generally limited to ways and means of stowing, using, accounting for, and disposing of such publications in accordance with existing directives. The basic Navy security directive relative to the safeguarding of classified information is the Department of the Navy Security Manual for Classified Information, OpNav Instruction 5510.1 (Series). Its provisions apply to all military and civilian personnel and to all activities of the Naval Establishment. The application of security measures regarding shop files may be further influenced by locally issued directives which supplement the basic directive.

All personnel in the Naval Establishment are individually responsible for assuring that knowledge of classified information which they prepare or handle is made available only to persons who have clearly established a legitimate "need to know." Classified material is procured for the work center files because it is needed during the performance of some related maintenance function. Use of these publications by powerplant personnel should be anticipated and steps taken to procure security clearances for selected personnel most likely to require the information.

The supervisor must initiate procedures that insure him positive control of all classified publications for which he is custodian. The first problem of custody is stowage. The Navy Security Manual discusses stowage containers of varying degrees of integrity. Also provided in the manual are specific requirements for safeguarding combinations and keys for locks as these, to various extent, affect the protective capabilities of the different types of containers.

Classified publications that are no longer required in the work center should be returned to the Classified Material Control Officer for disposition by transfer or destruction, as appropriate.

MAINTAINING WORK CENTER FILES

There are two general categories of records required of all work center supervisors. These include records required by the activity for operational purposes and those needed by the work center chief for the efficient management of his work center. It is advisable to keep the system of records as simple as possible and still maintain the necessary control. Too few records, however, can lead to uncertainty, encourage guessing, and sometimes lead to embarrassing situations. In order for records to be of maximum benefit and provide adequate control, it is necessary that records and publications be filed in the work center in such a manner that they may be quickly located.

The Navy has adopted a filing system which provides a definite place for every piece of correspondence and uniformity in filing systems throughout the Naval Establishment. In the relatively few years this system has been in use its merits have greatly exceeded any real or imagined disadvantages. The filing system is an integral part of the Directives Issuance System. The 13 major subject classification group numbers are further subdivided into primary, secondary, and sometimes, tertiary breakdowns. Each subject group symbol must have 4 or 5 digits to be complete. Example of subject classification number breakdown:

13XXX—Aeronautical and Astronautical Material.

134XX—Systems, Components, and Accessories.

13430—Arresting and Launching, Provisions for.

13430.1—Airplane Arresting Hooks, Inspection and Replacement.

While directives (Instructions and Notices) utilize the standard subject group classification numbers and breakdowns of the Directives Issuance System, many other types of publications do not. When file materials other than Instructions and Notices are received in the shop,

they should be assigned a file symbol based on the subject group classification number. The correct application of file symbols assures uniformity in filing.

Personnel who have a working knowledge of the subject classification system and the manner in which all records are filed can locate required material expeditiously at any activity to which they may be assigned.

The most important filing operation is classifying (assigning file symbols) since it determines where papers are to be filed so that they may be located quickly. Each paper received in the work center for filing should have the work center file symbol assigned regardless of whether or not a file symbol already appears on it. The proper coding should be determined by the most important, definite, or concrete subject mentioned; the purpose or general significance of the document; the manner in which similar documents are sought; and the file symbol under which other documents of a similar nature are filed.

The actual filing responsibility should be assigned to one person in the work center. All material awaiting filing should be placed in one basket only; and to avoid accumulations, should be filed daily.

When material could be properly filed under two or more headings, one or more cross-reference forms should be inserted in the files at the appropriate places to indicate just where the document is filed. The cross-reference should indicate the following:

1. Originator of the letter, serial number, file symbol, and date.
2. Addressor of letter.
3. Subject of letter.
4. Addressee of letter.
5. Where letter is filed.
6. Brief of letter or applicable part of text.

Extra copies of the basic document may be used instead of the cross-reference form. Cross-referencing, while serving a useful purpose, should be kept to a minimum to conserve space.

Another handy tool for keeping work center files in good order is the "file out" card. This may be a locally prepared form that is inserted into the files whenever a piece of file material is charged out to another office, work center, or person, to help keep track of its whereabouts. All "file outs" should be checked periodically to prevent misplacement of material. Care must be taken that records are not released to unauthorized persons.

A ready index should be provided in the work center so that material may be more easily located. The index should be set up according to the 13 major subject classifications in the Directives Issuance System and further subdivided into categories corresponding to the list of standard subject classification numbers contained in SecNav Instruction P5210.11 (Series), Standard Subject Identification Codes.

REQUIRED READING AND MAINTENANCE INFORMATION RECORD

Certain directives and publications are routed to the various work centers as maintenance information, and copies of such maintenance information must be disseminated and retained until it is no longer applicable. Information should be placed in a required reading file that is available to all hands in the work center. When new material is received, it is placed in the "active" required reading file until it is read and initialed by each man in the work center. It may be necessary for the work center supervisor to amplify or clarify some information so that it will be properly understood.

Once all personnel in the work center have read and initialed the material, it is placed in the "standing" required reading file for use in indoctrinating new personnel and for periodic review by those personnel who may require it. Newly assigned personnel should read and initial both the active and standing files. If copies of directives or publications are not available for required reading file, a cross-reference sheet indicating the general content of the subject matter and its location is utilized to insure that personnel are throughly aware of all information that could affect their actions.

TRAINING OF PERSONNEL

Training of personnel is a necessary function and one of the most important responsibilities of senior petty officers. A Chief Aviation Machinist's Mate J and to some extent a First Class, will have regular and continuing responsibilities for the training of others. Even if a supervisor is fortunate enough to have a group of men who are highly skilled and well trained, he will find that training is still necessary. For example, the training of strikers and lower rated men for advancement examinations is a continuing, never-ending process. The Navy rotation

policy being what it is, the best men will eventually be transferred and replacements will, in most instances, require training before they can be relied on to take their places as effective members of the organization. These and similar problems require the powerplants supervisor to be well versed in the several aspects of training—able to set up as well as conduct an effective training program for assigned personnel.

ORGANIZING A TRAINING PROGRAM

Organizing a training program involves such considerations as planning lessons and job plans, selecting and qualifying instructors, making arrangements for classroom space, phasing the training program with the scheduled workload, procuring visual and other training aids, and determining teaching methods for each lesson or lesson series.

The subject matter areas to be included in the training program are (1) material relating to maintenance of aircraft supported, (2) general material required by the men for advancement examinations, and (3) material relating to safety. In most cases lessons will fall under more than one of the subject areas.

Once it has been determined what publications will adequately cover the subject areas, the material must be divided into lessons, and lesson guides prepared. The lesson guides for each lecture are prepared in accordance with the standard format provided in OpNav Instruction 4790.2 (Series). The lectures are numbered to provide a means of recording each man's progress within his individual training folder. A training syllabus sheet should be prepared for each man in the work center to provide a handy index to the state of training of the work center personnel as a whole.

Whether the supervisor teaches the lessons himself or assigns other petty officers to conduct them depends on the state of training of his first and second class petty officers. A requirement for advancement for third class petty officers and nonrated personnel is satisfactory completion of the correspondence course based on Military Requirements for Petty Officer 3 & 2, NavPers 10056 (Series). This course sets forth some of the basic principles of training in general and teaching in particular.

An advancement requirement for second and first class petty officers is satisfactory completion of the correspondence course based on Military Requirements for Petty Officer 1 &C, NavPers 10057 (Series). The latter course expands and amplifies training theory and introduces job analyses, training aids, and testing. For the first time in his career the prospective First Class Aviation Machinist's Mate J is required to demonstrate his ability to formally teach, use various training aids, and prepare and administer written tests. In order to demonstrate correct instructional techniques, the supervisor may elect to teach certain lessons himself or assign them to a competent instructor for the same purpose. Later he may assign less proficient petty officers as instructors so that they may acquire the experience necessary for completing their practical factors for advancement.

If at all possible, training sessions should be conducted at the same time of day and on a regular schedule. Factors to consider when scheduling lessons are usual flight schedule, meal hours, watches, availability of classroom, and aircraft inspection schedule.

Some lessons are better suited for one type of instructional technique than others. The type of presentation for each lesson should be planned in advance. This will also facilitate the rotation of the lessons among the petty officers who require experience in teaching.

The effectivity of aviation technical training is greatly enhanced by the use of training aids. The supervisor should always be on the alert for scrap material that can be converted to training aids with minimum expense. He must be aware of the existence of applicable training films and, if they are available, schedule them for showing in conjunction with specific lessons. The squadron or unit safety officer or station safety engineer may usually be depended on to supply training aids in support of shop safety presentations.

When planning a training program, the supervisor should decide where the classroom sessions should be conducted. The space selected should preferably be in a quiet area or at least one with a minimum of noisy distractions. The area should be large enough to accommodate the expected student load and be well lighted. Adequate ventilation will help keep the men awake and interested in the presentation. Convenience is another factor in the selection of classroom space. Some of the desirable space characteristics may, on occasion, have to be sacrificed in order to find a classroom nearer to the working area.

TRAINING PROCEDURES

Training procedures are of two general types—formal and informal.

Formal training is conducted in the classroom through lectures, supplemented by required reading and implemented by the use of all available visual aids. A schedule of training is prepared and published periodically by the maintenance officer. It lists the time of the training, the location of the classroom, the names of the men who are to attend, the subject of the lesson, and the name of the instructor.

Lesson guides are prepared by the division officer and chief or first class petty officers who are qualified to do so. The lesson guides should contain the title, objective(s), time to be consumed in presenting the lesson, list of instructional aids, list of references, outline for presentation, and a summary of the lesson.

When a petty officer has been assigned to instruct a given lesson, it is his responsibility to procure a copy of the lesson guide and from it prepare his lesson plan. Lesson plans are prepared by each individual instructor based on the lesson guide; and though they may differ from instructor to instructor, they must adequately cover the subject.

Informal training is the practical instruction of men in the performance of maintenance tasks by means of demonstration and imitation under personal supervision in the work center or on the operating line. Nearly every maintenance task that is undertaken presents an opportunity for on-the -job training. The experienced men of the division are utilized as fully as possible in demonstrating and imparting their skills to the less experienced.

Under this system, the trainee has the opportunity to actually do the job under the supervision of an experienced petty officer. The only equipment necessary is the job itself. It is necessary, of course, that the instructor have an interest in the job and the skill to do it well. The striker or trainee will learn by seeing the job performed, and he will gain experience by having a chance to participate in the accomplishment of the job.

The nature of informal training makes regular scheduling impracticable. Actually, it is done at every opportunity. A training syllabus is prepared under the guidance of the maintenance officer, with content and scope corresponding with practical factor requirements of the personnel. On-the-job training is reported by the leading petty officer instructors and supervisors to the division officers on the training syllabus at regular intervals so that a close watch may be made on individual progress. The records are for review by higher authority and will point out the need for training in special areas as well as certain practical factors. The degree of success in on-the-job training depends on the degree of recognition by each individual of his responsibility to his outfit to impart his skill and knowledge to the man who is trying to learn.

TRAINING DOCUMENTATION AND RECORDKEEPING

Maintenance activities, except those that are specifically excluded, should comply with the manhour accounting procedures outlined in OpNav Instruction 4790.2 by submitting manhour accounting cards to reflect the accomplishment of formal inservice training. Procedures for submitting manhour accounting cards are provided in Military Requirements for Petty Officer 3 & 2, NavPers 10056 (Series) and OpNav Instruction 4790.2.

The individual Training Syllabus Sheet provides a record of formal lectures attended by each man in the work center. A report of practical training (OJT) should be made to the division officer at regular intervals. This will indicate to the division officer that a man has fulfilled a satisfactory level of skill to justify completing of the various items listed on the individual's practical factors for advancement sheet. The formal training syllabus record and the record of practical training will indicate that required training has been completed in all areas or that a need for special training exists and further certifies when the individual may be considered qualified for advancement.

CHAPTER 4

JETCAL ANALYZER

Of the many factors affecting jet engine life, efficiency, and safe operation, two of the most important are exhaust gas temperature (egt) and engine speed. Excess exhaust gas temperature of a few degrees will reduce turbine blade life as much as 50 percent. Excess exhaust gas temperature resulting from excess engine speed can cause premature engine failure. Either of these conditions makes engine operation extremely dangerous. Low exhaust gas temperature materially reduces jet engine efficiency and thrust.

Though the jet calibration test units used by the Navy include the BH112J-24, BH112J-30, and BH109C models, most of the coverage in this chapter is centered around the BH112J-30 unit. This unit is considered to be representative of the models with which the ADJ will be working.

Indications of fuel system troubles, tailpipe temperature, and rpm can be more accurately checked from the jet calibration test unit than from the gages in the cockpit of the aircraft. Errors of up to 10° C may be made in the interpretation of the temperature gages due to the height of the observer in the seat. Similarly, but to a smaller extent, errors may be made in interpretation of tachometers. With proper utilization of the jet calibration test unit, such errors can be greatly reduced.

DESCRIPTION OF THE JETCAL ANALYZER

The jet calibration test unit used to analyze the jet type engine is the jetcal or jetcal analyzer. The jetcal analyzer is a rugged, portable instrument fabricated of aluminum, stainless steel, and plastic. (See fig. 4-1.) Wheels, an adjustable handle, and a support post are attached to the jetcal analyzer box. The major components of the analyzer are the thermocouple, rpm, egt indicator, resistance, and insulation check circuits; potentiometer; temperature regulator; meters; switches; and all the necessary cables and adapters for performing all tests. The jetcal analyzer also includes the fire-warning, overheat detection, and wing anti-icing system test circuits.

Storage is provided within the analyzer for all the probes, cables, and adapters. The basic box is aluminum and has four compartments: probe, cable storage, instrument, and battery. Two snap action fasteners hold the lid closed; two snap action fasteners hold the probe storage compartment in place; one twist-to-lock fastener holds the cable storage compartment door closed. When using the analyzer, one self-locking support arm holds the lid open; two self-locking support arms hold the probe storage compartment open. (See fig. 4-3.)

PROBES

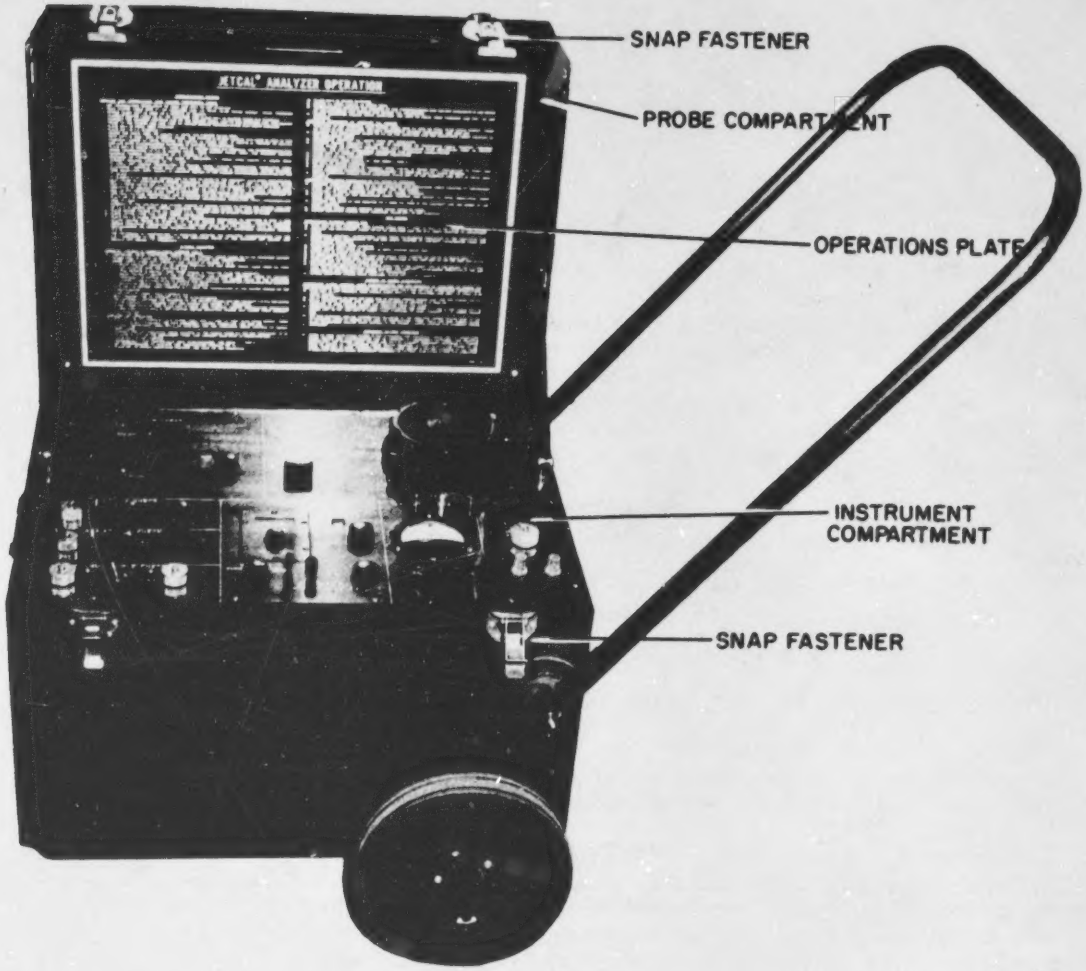
One of the key elements of the jetcal analyzer is the heater probe. Virtually a "furnace" of great efficiency, the probe is small and light in weight and will attain a temperature of 800° C in approximately 7 minutes. This rapid temperature rise enables the quickest possible engine test.

Tempcal probes are also furnished with the jetcal analyzer. These probes are designed for checking fire-warning, overheat detection, and wing anti-icing systems on the aircraft.

The heater probe and tempcal probe are discussed in the following paragraphs.

Heater Probes

The heater probe assemblies, which fit over the engine thermocouples, are made in a variety of sizes to fit various types of thermocouples. (See fig. 4-2.) The cables of the heater probes have quick disconnects standard to junction box assemblies, making the probes readily removable or replaceable.

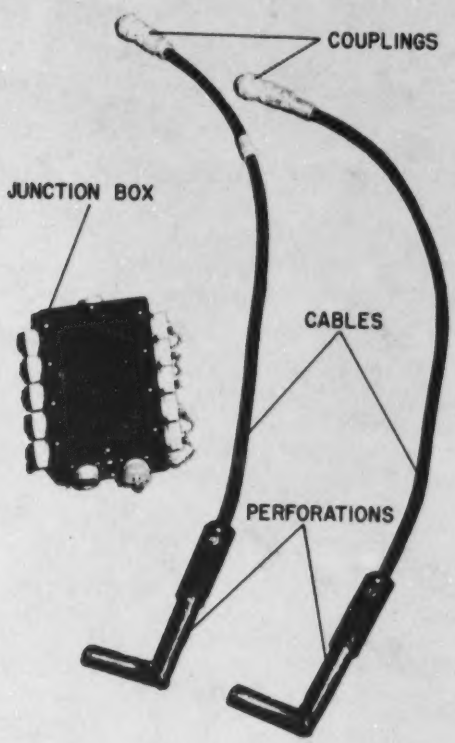


AD.214

Figure 4-1.—Jetcal analyzer.

Only heater probe assemblies with identical part numbers and heater probe cables of equal length can be combined to perform a functional test. Both the design of the heater and the length of the cables prohibit interchangeability of the different heater probes and unequal cable lengths. Combining heater probe assemblies of different part numbers and heater probe cables of unequal lengths will give erroneous parallel readings. The probes utilize wire-wound resistance heaters designed to give rapid temperature rise. Heater capacity is sufficient to test an engine at operating temperature when the ambient temperature is minus 55° C (minus 67° F). Perforations in the stainless steel tube keep the phenolic handle sufficiently cool to allow the probes to be moved from engine to engine while remaining at test temperature.

A calibrated chromel-alumel thermocouple is embedded in the heater in such a manner that



AD.215

Figure 4-2.—Heater probes and junction box.

the deteriorating effects of reducing and oxidizing atmospheres are negligible. A triangular spring of heat-resistant metal is mounted in the nosepiece to assure positive locking to the engine thermocouples. The resistance of the thermocouple circuit of each type of heater probe assembly and each cable length is exactly balanced and matched to a standard. The matched resistance allows probes of the same part number and cables of equal length to be used interchangeably.

Heater probe assemblies can never be repaired in the field because the resistance in the legs of the parallel harness is extremely critical and must be held to established standards to assure the correct temperature average of the heater harness.

The junction box parallels the power and thermocouple circuits of the heater probes. Junction boxes are available in 5-, 8-, 10-, and 12-outlet sizes to accommodate different numbers of heater probes. (See fig. 4-2.) The 12-outlet junction box is the one commonly used, since it will accommodate the different numbers of probes found in the various jetcal analyzers used by the Navy.

Tempcal Probe

The tempcal probe connects to the end of the heater cable and is used to functionally check fire-warning, overheat detection, and wing anti-icing systems on the aircraft. The tempcal probe is placed over thermal switches on the aircraft to functionally check the system. The temperature of the probe is raised or lowered to take the switch through its operating cycle. The tempcal probe is available in either straight or right angle configurations, and in different sizes to test different sizes and makes of thermal switches.

BATTERY COMPARTMENT

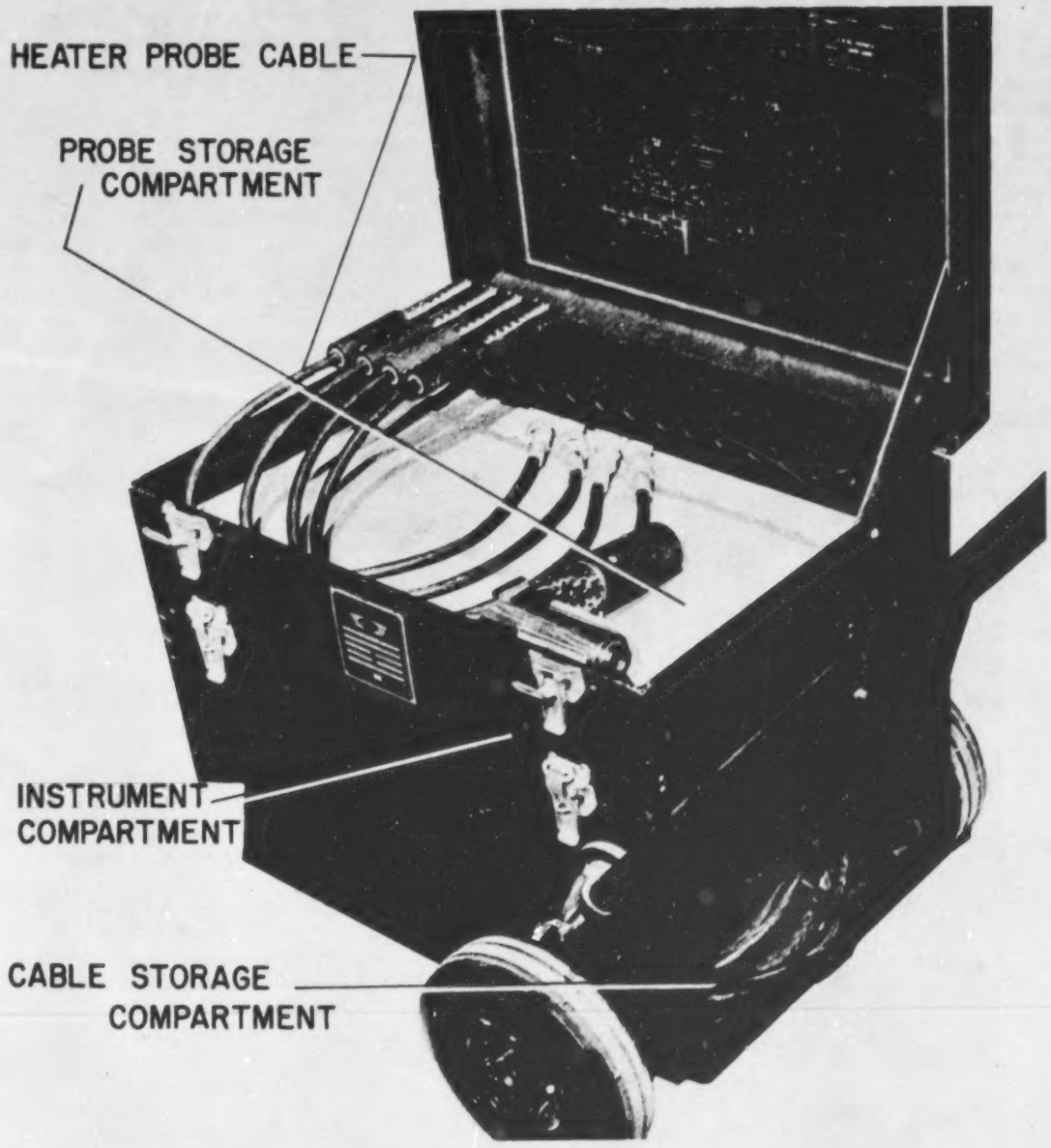
The battery compartment contains nine batteries; two are used for the potentiometer circuit; two are used for the egt, insulation, and resistance check circuits; five are used for the galvanometer light when the potentiometer is used on emergency battery operation. These batteries are mounted on a rack in the compartment and are accessible when the compartment cover is removed. (See fig. 4-4.) All battery locations are appropriately marked. The batteries supplied with the jetcal analyzer are of 1.35 volts. The proper cell must be used whenever replacement is necessary. The coil operates at temperatures as low as minus 55° C (minus 67° F). If a replacement dry cell other than the proper cell is used, the temperature limits of the jetcal analyzer are materially reduced. When replacements are necessary, check applicable instructions for the proper cell.

INSTRUMENT COMPARTMENT

The instrument compartment contains the jetcal analyzer circuits, instruments, switches, and receptacles required for the operation of the analyzer. (See fig. 4-5.)

Power Supply

The jetcal analyzer operates on any 95- to 135-volt, 50- to 400-Hz, a-c power supply,



AD.216

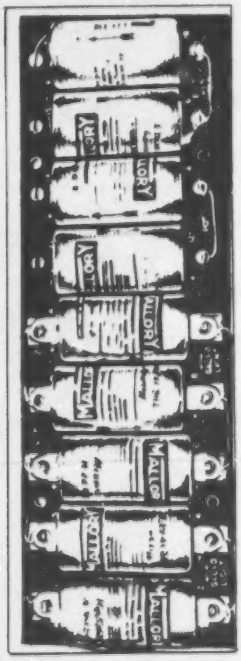
Figure 4-3.—Storage compartments.

and in temperatures from minus 55°C (minus 67°F) to 70°C (158°F). A 95- to 135-volt, a-c power supply must be used for the rpm check and the thermocouple check. All other operations can be performed by using emergency batteries when 95 to 135 volts (a-c power supply) are not available. The batteries are operated by a pushbutton switch. When the switch is released, the batteries are out of the circuit. However, the switch can be depressed when using 95 to 135 volts (a-c power supply) without damaging the batteries. To preserve the life of the emergency batteries, use 95 to 135 volts (a-c power supply) whenever possible.

NOTE: The NC-5 portable powerplant may be used as a source of power for the jetcal analyzer.

Fuses

A 20-ampere fuse is located in the heater probe power circuit. A 2-ampere fuse is used in all other fused circuits. A high resistance light in each fuse holder indicates a blown fuse.



AD.217

Figure 4-4.—Battery assembly.

Galvanometers

The two galvanometers used with the jetcal analyzer are galvo-1 and galvo-2. Galvo-2 is used only during the rpm check. (See fig. 4-6.) On all other tests galvo-1 is used.

Mechanical Zero Knob

This knob is used to mechanically zero galvo-2 when the selector switch (SW-7) is in the MECH ZERO position. This switch is also used to zero galvo-1 mechanically when switch (SW-6) is in the MECH ZERO position.

Percent RPM Dial Knob

This knob is used to adjust the scale of the rpm check to the percent rpm signal output of the tachometer-generator. The scale of the rpm check is calibrated directly in percent rpm.

Percent RPM Reading Window

This window shows the scale of the rpm check. The scale is read when the selector switch (SW-7) is in the range position. The rpm check scale is calibrated in intervals of 0.2 percent from 0 to 110 percent on the model BH112J-30 tester. The scale on the model BH112J-24 has a fine and a coarse range.

Potentiometer Temperature Scale

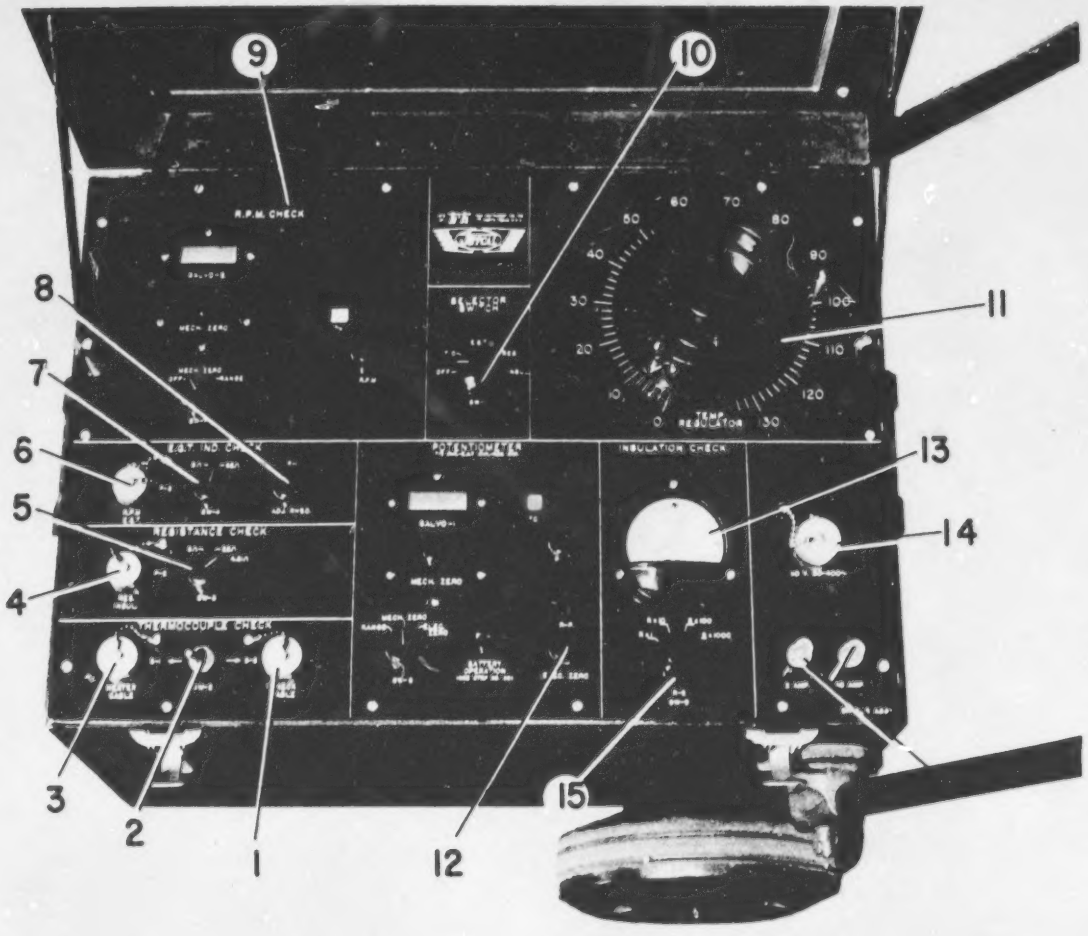
This scale is stamped on the tape that arries the voltage divider in the potemtiometer. The scale is calibrated in degrees Celsius (centigrade) in 1° increments and is read through the window marked °C.

CABLE STORAGE COMPARTMENT

The cable storage compartment is used to store all cables and adapters, the junction box, the switchbox, and the extension handle. (See fig. 4-6.)

Power Inlet Cable

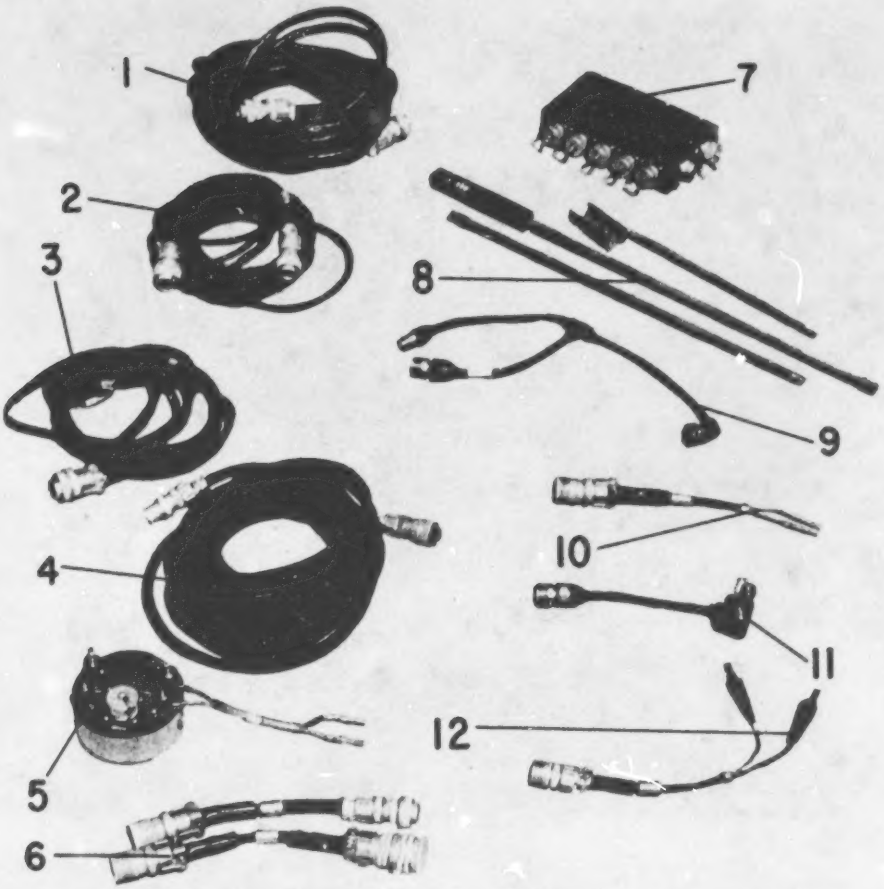
This 10-foot, 3-wire cable has a 3-hold female plug, which adapts to the male receptacle on the jetcal analyzer, and a conventional male plug for connecting to standard power outlets. The third wire is used as a pigtail ground wire for safety of personnel using the jetcal analyzer.



AD.218

1. Check cable receptacle (S-2).
2. Heater cable — check cable switch (SW-2).
3. Heater cable receptacle (S-1).
4. Resistance insulation check input receptacle (P-2).
5. Resistance check selector switch.
6. Tachometer — egt indicator check input receptacle (P-3).
7. Egt indicator selector switch (SW-4).
8. Egt indicator adjusting rheostat.
9. Rpm check (takcal unit).
10. Selector switch (SW-1).
11. Temperature regulator.
12. Potentiometer.
13. Insulation check meter.
14. Power input receptacle (P-1).
15. Insulation check meter operating knob.
16. Fuses.

Figure 4-5.—Instrument compartment, BH112J.



AD.219

1. Heater cable.
2. Check cable.
3. Power inlet cable.
4. Instrument cable.
5. Switchbox.
6. Check cable adapters.
7. Junction box.
8. Extension handle.
9. Rpm check adapter.
10. Egt indicator check adapter.
11. Resistance check adapter.
12. Insulation check adapter.

Figure 4-6.—Cable storage compartment contents.

Heater Cable

The 5-wire, 20-foot heater cable connects the jetcal analyzer to the junction box and heater probes. It has two copper leads for transmitting power and two copper-constantan leads for transmitting the voltage output of the heater probe thermocouples. The fifth wire provides a continuous ground circuit.

Check Cable

The 24-foot check cable connects the jetcal analyzer to the engine junction box (by means of the check cable adapter) or to the switchbox. It uses copper-constantan leads to transmit the voltage output of the aircraft thermocouples.

Check Cable Adapters

The short check cable adapters adapt the check cable to the connectors in the junction boxes of the various aircraft.

Instrument Cable

This 24-foot cable connects rpm, egt indicator, resistance, and insulation check circuits in the jetcal analyzer to the aircraft by means of adapters. (See fig. 4-6.)

Switchbox

The switchbox contains a 2-pole, 2-position rotary switch; two sets of copper-constantan terminal posts; and one set of copper-constantan leads. (See fig. 4-7 for a closeup view.) When the switchbox is used, it is placed in the thermocouple circuit at the aircraft egt indicator and is connected to the jetcal analyzer by means of the check cable. The voltage output of the aircraft thermocouples can be read on either the aircraft egt indicator or on the jetcal analyzer potentiometer, depending upon the switch position. If the engine thermocouple output is to be read on the potentiometer in the jetcal analyzer, the switch on the switchbox is placed in the jetcal position. (See fig. 4-7.)

Extension Handle

The extension handle is used to place heater probes on engine thermocouples that are difficult to reach. The extension handle has a friction grip that slips on and off the heater probe handles. Sectional extensions, as required, may be used. In the field, the extension handle gripping section can be bent to any desired shape, so that the contour will allow the operator to conveniently place the heater probes on the thermocouples that are difficult to reach.

Copper-constantan is used in the heater cable, check cable, check cable adapters, and switchbox for two reasons. Copper-constantan gives the cables more flexibility and inserts a minimum of resistance (less than 0.05 ohm) in the aircraft circuit. The voltage (emf) curves of copper-constantan and chromel-alumel are identical in the ambient temperature range. Heater probe cables and heater probe thermocouples are made of chromel-alumel.

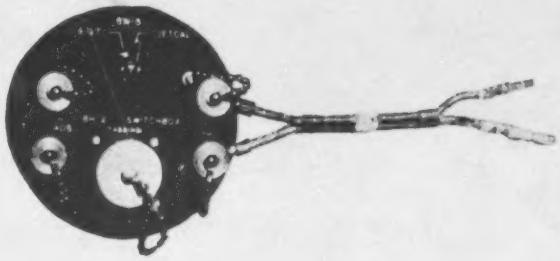


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Figure 4-7.—Switchbox.

USES OF THE JETCAL ANALYZER

The jetcal analyzer has 12 primary and separate uses. It is used as follows:

1. To functionally check the entire jet aircraft egt system for error without running the engine or disconnecting the wiring.
2. To check individual thermocouples as a bench check before placement in the parallel harness.
3. To check each engine thermocouple in the parallel harness for continuity.
4. To check the thermocouples and parallel harness for accuracy.
5. To check the resistance of the egt circuit, without the egt indicator, to within allowable limits of applicable technical instructions.
6. To check the insulation of the egt circuit for shorts to ground.
7. To check the egt circuit for shorts between leads.
8. To check egt indicators (either in or out of the aircraft) for error.
9. To check the engine thermocouples and parallel harness on the engine, with the engine removed from the aircraft.
10. To determine engine rpm with an accuracy of plus or minus 0.1 percent during engine runup. Added to this is the checking and troubleshooting of the aircraft tachometer system.

11. To establish the proper relationship between the egt and engine rpm on engine runup during tabbing (micing) procedures by use of the rpm check (takcal) and potentiometer in the jetcal analyzer. (Tabbing procedures are those procedures followed when fixed or variable exhaust gas tail cone areas are properly adjusted during normal check of aircraft.)

12. To check aircraft fire detector, overheat detector, and wing anti-icing systems by using tempcal probes.

PRINCIPLES OF OPERATION

The principles involved in the operation of the jetcal analyzer are varied and many. In this section some of the basic principles are described.

HEATER CIRCUIT

The operation of the heater circuit depends on the principle of a wire-wound resistance heater and a variable voltage regulator.

Wire-Wound Resistance Heater

When a voltage is applied to a high resistance wire, the energy dissipated across this voltage drop evidences itself as heat. The amount of heat energy generated across this voltage drop is dependent upon the line voltage applied and the amount of resistance of the wire in the circuit. The final temperature of the wire-wound heater will be attained when the heat energy input equals the heat losses due to convention, conduction, and radiation.

Variable Voltage Regulator

When a wire is looped into a circle and an alternating current is allowed to flow through this circuit, a fluctuating magnetic field surrounds this loop. If another loop of wire is placed within this fluctuating magnetic field, a current will flow in this new circuit, which is induced by this fluctuating magnetic field of the primary coil. The voltage induced in the secondary coil is found to be of the same proportion as the voltage in the primary coil. Thus, the primary voltage and the secondary voltage are proportional to the number of turns in each winding. For example, if the secondary has twice as many turns as the primary, the voltage induced in the secondary will be twice the voltage in the primary. This is the principle of a transformer.

A variable voltage regulator is a transformer whose primary voltage and the number of turns are a fixed quantity. The secondary coil is the variable quantity and is provided with a brush contact which can vary its number of turns. At the will of the operator the voltage of the secondary can then be varied to the output voltage desired.

The wire-wound resistance heaters are connected into a parallel circuit in the junction box. (See fig. 4-8.) The heaters have approximately the same internal resistance; and since the same voltage is applied to each heater (due to a parallel circuit), they will be approximately the same temperature. The output of the voltage regulator applied to the heaters can be varied from 0 to 135 volts. This should vary the temperature on the heaters from 0° to approximately 900°C, depending upon the line voltage available. The voltage regulator or circuit is a separate fused circuit.

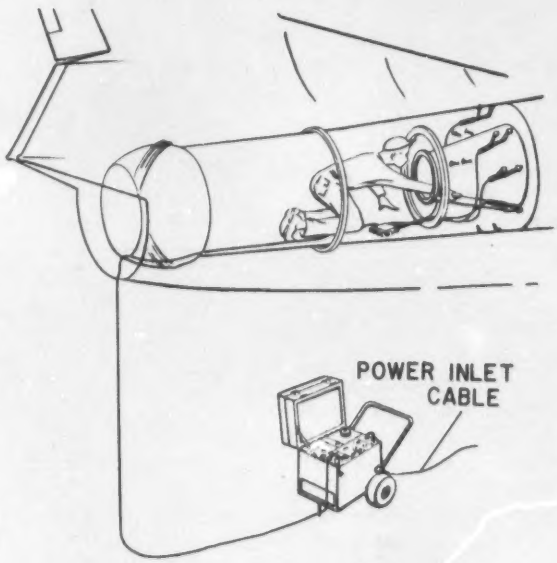

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Figure 4-8.—Installation of heater probes.

TEMPERATURE MEASURING CIRCUIT

The operation of the temperature measuring circuit depends upon the phenomenon of thermocouple effect, the principle of an electrical parallel circuit, and the potentiometer principle.

Thermocouple Effect

If wires of different materials are placed in contact with each other at two points, and one junction is hotter than the other, a current is found to flow and a battery effect is evidenced. This is known as thermocouple effect. The voltage which gives rise to this current is dependent only on the metals involved and the temperature differences of the two junctions. Thus, by keeping one junction at a constant, known temperature, this circuit may be used as a temperature measuring device.

Parallel Circuit

When a set of batteries is wired in parallel, it acts as one single battery source. When the resistance is equal in each of the parallel legs of the circuit, the voltage output will be the arithmetical average of all the single batteries in the circuit. Therefore, if a group of thermocouples is wired in parallel and care is exercised to have all of the resistance of the legs equal, the total temperature registered on an instrument will be the exact average temperature of the group of thermocouples.

Potentiometer Principle

A potentiometer measures the potential difference, or voltage, between any two terminals without drawing current. First, the battery voltage is standardized through a variable resistor so that the battery voltage across an additional resistor is equal to the voltage of a known standard cell.

By applying this standardized voltage on the Wheatstone bridge circuit, the voltage divider, which is in the bridge circuit, can then be used to apply a back voltage to stop the flow of current in the external circuit. This null balance condition is shown as no current flow through the galvanometer. The galvanometer reads zero at this time. The voltage divider setting indicates on a scale the applied voltage of the external circuit. On the jetcal analyzer potentiometer, the scale is calibrated directly in degrees Celsius.

Galvo-1 and Galvo-2

The galvanometers used with the jetcal analyzer are used to establish a reference point so that an accurate reading may be obtained through the percent (%) window of the degree (° C) window. (See fig. 4-5.) To obtain a zero reading, both galvanometers can be adjusted manually through their respective control knobs. A zero indication must show through the galvo-1 or galvo-2 window before an accurate reading can be obtained in percent rpm or degrees Celsius.

RESISTANCE TEST CIRCUIT

The resistance test circuit is a resistance-measuring Wheatstone bridge, in which the thermocouple circuit of the aircraft is used as the unknown resistance. The galvanometer of the jetcal potentiometer serves as the null balance galvanometer for the bridge operation. Highly accurate chromel-alumel resistors are used as one leg of the Wheatstone bridge to match the temperature characteristics and circuit resistance of the aircraft chromel-alumel egt circuit.

The resistance spool (fig. 4-9) of the aircraft egt circuit is adjusted to match the standard resistor in the jetcal analyzer. A null balance condition of the galvanometer indicates a correct circuit resistance. The resistors of the resistance test circuit are made of the same material (chromel-alumel) as used in the aircraft egt circuit. Therefore, no temperature corrections are required. The resistors in the jetcal analyzer and the aircraft circuit will change resistance equally as the ambient temperature changes. When varying the spool resistance as shown in figure 4-9, insure that the insulation coating is removed at the connection.

INSULATION TEST CIRCUIT

The insulation test circuit uses the principle of an ohmmeter to detect the amount of leakage current across the insulation. Voltage from batteries contained in the jetcal analyzer is applied to the aircraft egt circuit leads and ground, or across the leads. The amount of leakage current to ground is detected by the moving coil of the insulation check meter and is measured directly in ohms. A potentiometer is used to adjust the insulation check meter for full-scale deflection when the leads are shorted together. The outside control is a switch which

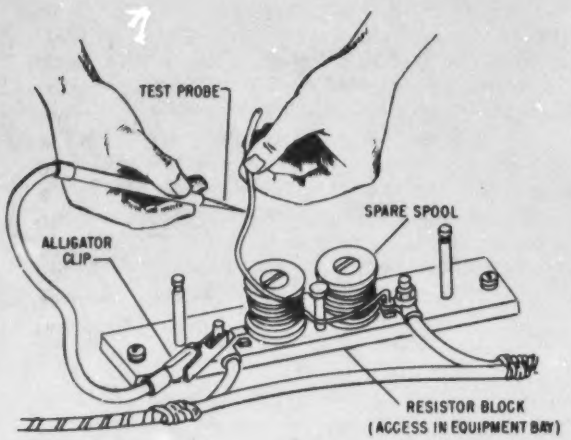

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Figure 4-9.—Resistor block.

is used to select the range of resistance values that will be read on the meter. (See fig. 4-5.) The meter can be used to read resistance values from 0 to 550,000 ohms.

EGT INDICATOR TEST CIRCUIT

The operation of the egt indicator test circuit depends upon an external battery whose voltage is dropped by a variable resistor to simulate the voltage output of a thermocouple. The resulting current is allowed to flow through the aircraft egt instrument. The potentiometer measures the voltage applied, since the voltage divider of the potentiometer is calibrated in degrees Celsius. The temperature equivalent to the voltage is read directly. This reading is compared with the reading of the aircraft egt indicator to determine the accuracy of the indicator.

The external battery circuit, contained in the jetcal analyzer, has a dual potentiometer with coarse and fine adjustments in series with the batteries. This allows the operator to drop the approximately 1 1/2-volt battery output to the equivalent millivolts of the thermocouples. This exact thermocouple voltage is measured by the potentiometer at this point and is read in degrees Celsius. No correction is required for ambient temperature changes, since both the potentiometer and the egt indicator have cold junction compensation. A rotary selector switch is used to place the resistor corresponding to the correct aircraft resistance between the simulated thermocouple voltage and the egt indicator. With the instrument cable and egt indicator adapter leads attached to the aircraft egt indicator terminals, the aircraft egt indicator reading should correspond to the potentiometer readings. The allowable limits of an aircraft egt indicator will vary, depending on the manufacturer or the type of instrument.

RPM TEST CIRCUIT

The rpm test circuit is a frequency meter on which the frequency of the tachometer-generator is read. The circuit is insensitive to voltage and is practically independent of the voltage of the tachometer-generator, since it will operate on 1 1/2 volts and 1/2 micro-ampere. When using the rpm check circuit, the operation of the aircraft tachometer system is not affected because of the low current required by the rpm check circuit.

The single scale of the rpm check circuit is calibrated from 0 to 110 percent rpm to correspond to the engine rpm. Therefore, the frequency of the tachometer-generator is read directly in percent engine rpm. The rpm check circuit uses a null balance galvanometer, and all readings are made when the galvanometer reads zero.

OPERATING INSTRUCTIONS

The complete step-by-step procedure on the operation plate of the jetcal analyzer should be followed during actual operation of the analyzer. The operation plate is visible at all times when operating the analyzer. With the jetcal analyzer close at hand, performing the step-by-step procedure is a simple and easy operation.

It would be useless to list the step-by-step procedure in this test. The procedure consists of turning on or off many separate switches and dials. Without the analyzer close at hand to perform the steps, the procedure would be confusing and hard to follow. To avoid confusion and loss of interest, this section is confined to the operation of the jetcal analyzer in a general sense.

SAFETY PRECAUTIONS

The following safety precautions must be observed while operating the jetcal analyzer:

1. Never use a voltohmmeter to check the potentiometer for continuity. If a voltohmmeter

is used, damage to the galvanometer and standard battery cell will result.

2. Check the thermocouple harness before engine runup. The thermocouple harness must be checked before engine runup because the circuit must be correct before the thermocouples can be used for true egt pickup.

3. For safety of personnel, ground the jetcal analyzer when using an a-c power supply. Any electrical equipment operated on a-c power and utilizing wire-wound coils, such as the probes with the jetcal analyzer, has an induced voltage on the case that can be discharged if the equipment is not grounded. This condition is not apparent during dry weather, but on damp days the operator can be shocked slightly. Therefore, for the operator's protection, the jetcal analyzer should be grounded while being used.

4. Use heater probes designed for use on the engine thermocouples to be tested. Temperature gradients are very critical in the design of heater probes. Each type of aircraft thermocouple has its own specially designed probe. Never attempt to modify heater probes in the field to test other types of thermocouples. Heater probe assemblies can never be repaired in the field because the resistance in the legs of the parallel harness is extremely critical and must be held to established standards to assure the correct temperature average of the heater harness.

5. Do not attempt to repair junction boxes, heater cables, instrument cables, or instrument cable adapters. An attempt to repair these items will affect circuit tolerances and introduce errors in the jetcal analyzer.

6. Do not leave heater probe assemblies in the tailpipe during engine runup.

7. Never allow the heater probes to go over 900°C (1,652°F). Exceeding these temperatures will result in extreme damage to the jetcal analyzer and heater probe assemblies.

8. Replace jetcal batteries with only the proper batteries. If the improper cell is used, the temperature limits of the jetcal analyzer are materially reduced.

9. If the operator suspects the jetcal analyzer is not functioning properly, he must notify the department concerned with the maintenance of the jetcal analyzer before proceeding with any tests.

CONTINUITY CHECK OF AIRCRAFT EGT CIRCUIT

In order to eliminate an error due to one or more aircraft thermocouples being inoperative, a continuity check is performed. The check is made by heating one heater probe between 500° and 700°C and placing the hot probe over each of the aircraft thermocouples, one at a time. The egt indicator must show a temperature rise as each thermocouple is checked. When large numbers of thermocouples are used in the harness (eight or more), it is difficult to see a rise on the aircraft instrument because of the electrical characteristics of a parallel circuit. Therefore, the temperature indication of the aircraft thermocouples is read on the potentiometer of the jetcal analyzer, using the check cable and necessary adapter.

FUNCTIONAL CHECK OF AIRCRAFT EGT CIRCUIT

The time required to test the egt system of any one aircraft will depend upon several factors: The number of engines; the number of thermocouples in the harness, and their position in the engine; the errors, if any are found; and the time required to correct the errors. The normal function test of a single engine can be performed in 10 to 20 minutes; special conditions may require longer.

On the egt system functional test and the thermocouple harness checks, the jetcal analyzer has a guaranteed accuracy of plus or minus 4°C at the test temperature, which is usually the maximum operating temperature of the jet engine. Each engine has its own maximum operating temperature, which can be found in applicable technical instructions.

The test is made by artificially heating the engine thermocouples in the tail cone to the engine test temperature. The artificial heat is supplied by heater probes through the necessary cables. (See fig. 4-8.) Notice that the tailpipe is removed. With the engine thermocouples hot, their temperature is registered on the aircraft egt indicator. At the same time, the thermocouples embedded in the heater probes, which are completely isolated from the aircraft system, are picking up and registering the same temperature on the jetcal potentiometer in the jetcal analyzer.

The temperature registered on the aircraft egt indicator should be within the specified tolerance of the aircraft system and the temperature reading on the jetcal potentiometer. The thermocouples embedded in the heater probes are of Bureau of Standards accuracy; therefore, jetcal readings are accepted as the

standard and are used as the basis of comparison for checking the accuracy of the aircraft egt system.

Since the junction box is wired in parallel, it is not necessary to have heater probes connected to all the outlets of the junction box when making a check. On engines that have a balancing type thermocouple system, the balancing thermocouple must be removed from the circuit. The remaining thermocouples can be checked individually or together. The balancing thermocouple is checked, using a single probe. The output of the balancing thermocouple is also read on the jetcal potentiometer and compared to the heater probe thermocouple reading.

When the temperature difference exceeds the authorized allowable tolerance, the operator should troubleshoot the aircraft system to determine which parts are in error. Troubleshooting is discussed later in the chapter.

FUNCTIONAL TEST OF THERMAL SWITCHES

The tempcal probe functionally tests the operation of the fire detection, overheat, and wing anti-icing systems, which incorporates a thermal switch as the detection device. (See fig. 4-10.) The thermal switch is tested in position on the aircraft by placing the probe over the thermal switch. The tempcal probe incorporates the principles of the heater probe for its temperature pickup. The tempcal probe is connected to the heater cable. The temperature is regulated by the temperature regulator and is read on the jetcal potentiometer.

With the tempcal probe over the thermal switch, the temperature of the probe is raised and lowered to take the switch through its operating temperatures. The indicator on the aircraft instrument panel, generally a redlight, is then checked for indication to make sure that the switch is actuating at proper temperatures. If the system is not indicating properly, the circuit must be corrected.

If a hot tempcal probe is placed over a cold thermal switch, the contacts will close almost immediately due to an action called thermal shock. As the thermal switch continues to absorb heat, the contacts will open and then close again when the operating temperature of the switch is reached.

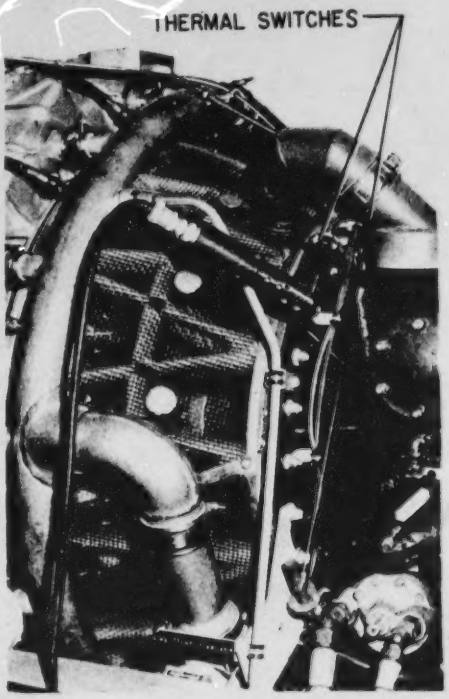

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Figure 4-10.—Testing thermal switch.

TEMPERATURE ADJUSTMENTS

The following procedure will aid the operator to make rapid, small adjustments of the temperature of heater probes:

1. Turn temperature regulator to maximum output. (See fig. 4-8.) Allow the heater probes to come to test temperature.
2. Turn the temperature regulator back to normal stabilizing voltage (approximately 96 to 108 volts for 700° C). Watch the galvanometer needle closely to see which way it drifts. Note the regulator setting.
3. For a few seconds, turn the regulator well above or below (according to drift) the noted setting.
4. Continue this procedure until heater probes are stabilized at test temperature. With a little practice, rapid adjustments of temperature can be made.

The time necessary to heat and stabilize probes will depend upon line voltage, ambient temperature, and air currents. Some engines, after being idle for some time, collect moisture on the thermocouple terminals and extra time has to be allowed for this moisture to evaporate. Normally, a 10-minute soak time will be sufficient. However, if after 10 minutes the system is not within limits, an additional 20-minute soak time should be allowed. If the system is still not within tolerance, the difference will be system error.

EGT INDICATOR CHECK

Test of the egt indicator is performed with the indicator removed from the aircraft instrument panel and disconnected from the aircraft egt circuit leads. Attach the instrument cable and egt indicator adapter leads to the indicator terminals and place the indicator in its normal operating position. Adjust jetcal analyzer switches to the proper settings. The indicator reading should correspond to the potentiometer readings of the jetcal analyzer within the allowable limits of the egt indicator.

Correction for ambient temperature is not required for this test, as both the egt indicator and jetcal analyzer are temperature compensated.

The temperature registered on the aircraft egt indicator should be within the specified tolerance of the aircraft system and the temperature reading on the jetcal potentiometer. The thermocouples embedded in the heater probes are of Bureau of Standards accuracy; therefore, jetcal readings are accepted as the standard and are used as the basis of comparison for checking the accuracy of the aircraft egt system.

When the temperature difference exceeds the authorized allowable tolerance, the operator should troubleshoot the aircraft system to determine which part or parts are in error.

When the aircraft egt is not attached to the aircraft instrument panel, hold the indicator in the normal operator position for a more accurate check.

RESISTANCE AND INSULATION CHECK

The thermocouple harness continuity is checked while the egt system is being functionally checked. The resistance of the thermocouple harness is held to very close tolerances, since a change in resistance changes the amount of current flow in the circuit. A change of resistance will give erroneous temperature readings.

The resistance and insulation check circuits make it possible for the operator to completely analyze and isolate any error in the aircraft system. How the resistance and insulation circuits are used is discussed later in the troubleshooting section.

TACHOMETER CHECK

To read engine speed with an accuracy of plus or minus 0.1 percent during engine run, the frequency of the tachometer-generator is measured by the rpm check (takcal) circuit in the jetcal analyzer. The scale of the rpm check circuit is calibrated in percent rpm to correspond to the aircraft tachometer indicator, which also reads in percent rpm. The calibration intervals are 0.2 percent.

The aircraft tachometer and the rpm check circuit are connected in parallel and both are indicating during engine runup. (See fig. 4-11.)

The rpm check circuit readings can be compared to the readings of the aircraft tachometer to determine the accuracy of the aircraft tachometer. During tabbing (micing) procedures, the engine speed is indicated on the rpm check circuit in percent rpm. The temperature indication of the thermocouple harness is indicated on the jetcal potentiometer with the use of the check cable and switchbox, with an accuracy of plus or minus 1°C. The engine exhaust gas tail cone areas are then adjusted to the proper tailpipe temperature at the proper percent rpm.

TROUBLESHOOTING

The jetcal analyzer will quickly and accurately test the EGT circuit of a jet aircraft, as a complete system, without running the engine or disconnecting the wiring. This test will immediately determine if the temperature system indicates within allowable limits. If the thermocouple system does not fall within allowable limits it is possible to troubleshoot the system to isolate errors. Troubleshooting of the EGT system as well as the aircraft tachometer system is discussed in the following paragraphs.

EGT SYSTEM

The jetcal analyzer is used to test and troubleshoot the aircraft thermocouple system

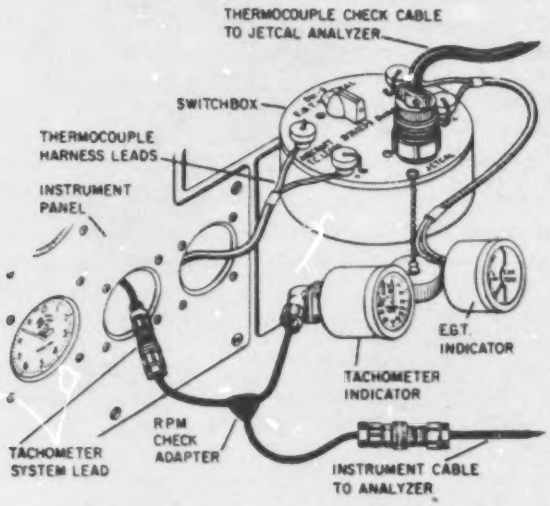

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Figure 4-11.—Switchbox and rpm check adapter connections.

at the first indication of trouble or on periodical maintenance checks. Before engine runup, the thermocouple harness must be checked for accuracy by using the jetcal heater probes. (See fig. 4-8.) Formerly, the reading of the engine thermocouple harness was accepted as correct. This assumption was erroneous due to the following inherent inaccuracies:

1. One or more thermocouples inoperative in engine parallel harness.
2. Engine thermocouples out of calibration.
3. Egt indicator error.
4. Resistance of circuit out of tolerance.
5. Shorts to ground.
6. Shorts between leads.
7. Crossing of lead wires.

If system error exceeds the specified tolerance, one or more causes listed above will probably be the source of trouble. The test circuits of the jetcal analyzer make it possible to isolate all of the troubles listed above, with the exception of crossed lead wires. Each trouble will now be dealt with in the order listed above, including crossed lead wires.

One or More Thermocouples Inoperative in Engine Parallel Harness

This error is found in the regular testing of aircraft thermocouples with a hot heater probe and will be a broken lead wire in the parallel harness or a short to ground in the harness. In the latter case the current from the grounded thermocouple can leak off and never be shown on the indicator. However, this grounded condition can be found by using the insulation resistance check.

Engine Thermocouples Out of Calibration

It has been found that when thermocouples are subjected for a period of time to strong reducing or oxidizing atmospheres, such as encountered in jet engines, they will drift appreciably from their original calibration. On engine parallel harnesses, when individual thermocouples can be removed, these thermocouples can be bench checked, using one heater probe. The temperature readings obtained from the thermocouples should be with manufacturer's tolerances.

EGT Circuit Error

This error is found by using the switchbox and comparing the reading of the aircraft egt indicator with the jetcal temperature reading. (Refer to fig. 4-11.) With switch SW-5 in the jetcal position, the indication of the thermocouple harness is carried back to the jetcal analyzer. With switch SW-5 in the egt position, the temperature reading of the thermocouple harness is indicated on the aircraft egt indicator. The jetcal and aircraft temperature readings are then compared.

Resistance of Circuit
Out of Tolerance

The engine thermocouple circuit resistance is a very important adjustment, since a high resistance condition will give a low indication on the aircraft egt indicator. This condition is dangerous, as the high resistance will make the indicator read low and the engine will be operating with excess temperature. Adjustment is generally made by adjusting a resistor located in the black box on the engine.

Shorts to Ground and
Shorts Between Leads

These errors are found by using the insulation check meter as an ohmmeter. Resistance values from 0 to 550,000 ohms can be read on the insulation check meter by selecting the proper range.

Crossing of Lead Wires

An odd number of crosses (1, 3, etc.) can be easily detected, since the egt indicator will read backwards upon application of heat to the aircraft thermocouples. An even number of crosses (2, 4, etc.), although much more difficult to detect, can be found by the several methods which follow.

1. The simplest method is with an ohmmeter. Chromel has approximately 2 1/2 times the resistance of alumel wire. Therefore, a chromel lead should have approximately 2 1/2 times the resistance of alumel wire. To have crossed leads, some of the opposite wire must be inserted into that lead, and it will show a resistance reading different from a 2 1/2 to 1 ratio.

2. Where possible, make a normal thermocouple test with the jetcal analyzer on a hot engine (shortly after being run). After the engine has cooled to ambient temperature, make another test. If there are crossed leads, the difference in the readings will probably be large because of the terminals that were present in the first test.

3. Each terminal can be disconnected and checked with a magnet. Chromel, which is the positive lead, is nonmagnetic. Alumel, the negative lead, is magnetic.

4. Touch a hot soldering iron to each terminal. A temperature rise or fall on the egt indicator indicates a transposition (crossing of lead wires) when the crossed terminal is touched.

After the functional check of the egt system with the jetcal analyzer has been accomplished and all inaccuracies have been corrected, the thermocouple harness reading will be accurate to within plus or minus 4°C. The thermocouple harness can now be depended upon for accurate temperature readings during engine runup.

All temperature readings made during engine runup (except during starting) are made on the jetcal potentiometer, and the aircraft egt indicator is checked for accuracy against the potentiometer temperature readings.

NOTE: During the starting procedure, the aircraft egt indicator is watched closely by the man starting the engine, so a hot start may be readily observed.

AIRCRAFT TACHOMETER SYSTEM

A related function of the rpm check is the troubleshooting of the aircraft tachometer system. The rpm check circuit in the jetcal analyzer is used to read engine speed during engine runup with an accuracy of plus or minus 0.1 percent. The connections for the rpm check are the instrument cable to the jetcal analyzer, the rpm check adapter to the instrument cable, and aircraft tachometer system lead to the tachometer indicator. (See fig. 4-11.) After the connections have been made between the jetcal analyzer rpm check circuit and the aircraft tachometer circuit, the two circuits (now classed as one) will be a parallel circuit. The engine is then run up as prescribed in applicable technical instructions. Both systems can be read simultaneously; however, the readings of the highly accurate rpm check circuit are used during tabbing (micing) procedures.

If the difference between the readings of the aircraft tachometer indicator and the jetcal analyzer rpm check exceeds the tolerance prescribed in applicable technical instructions, the engine must be stopped, and the trouble must be located and corrected. The following steps will assist the operator in locating and isolating the trouble:

1. If the aircraft tachometer error exceeds the authorized tolerance when compared to the rpm check reading, the instrument should be replaced. The engine rpm reading should be repeated by use of the rpm check circuit to check the instrument used for replacement.

2. If it is impossible to read 100 percent rpm on the aircraft tachometer, but the rpm check circuit does read 100 percent rpm, the trouble will be a bad aircraft tachometer indicator or a bad tachometer-generator. Replace the defective part or parts. The engine rpm reading should be repeated by use of the rpm check circuit to check the replaced parts.

3. If there is no reading on the aircraft tachometer indicator but there is a reading on the rpm check circuit, the trouble will either be a bad aircraft tachometer or an open or a grounded phase from the aircraft tachometer-generator. Replace the defective aircraft tachometer or tachometer-generator or repair the defective lead. The engine rpm reading should be repeated by use of the rpm check circuit to check replaced parts.

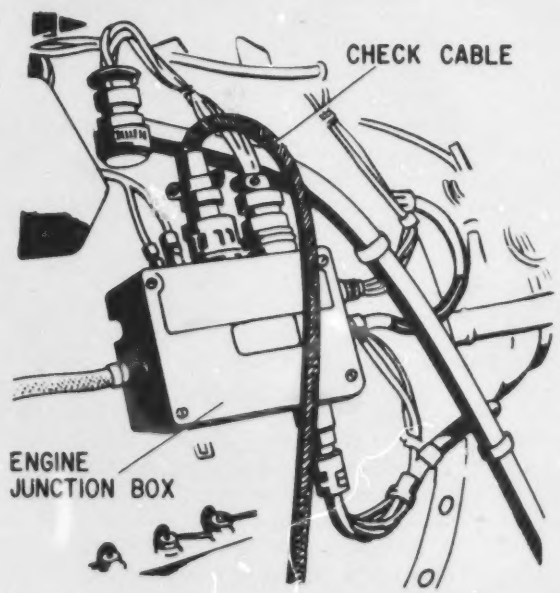
4. If there is no rpm indication on either the aircraft tachometer or the jetcal analyzer rpm check circuit, there will be an open or shorted lead in the aircraft circuit or a defective tachometer-generator. The defect in the aircraft circuit should be located and corrected, or the tachometer-generator should be replaced. The engine rpm reading should be repeated by use of the rpm check circuit to check replaced parts. After the above discrepancies have been corrected or if the system is within tolerance, the engine tabbing or nozzle scheduling can be safely started.

The jetcal analyzer is used for engine tabbing or nozzle scheduling because engine speed and exhaust temperature are extremely critical in engine operation. When the engine is to be checked and tabbed, the most convenient way to do this is to put the switchbox in the egt circuit and make the connections for the rpm check at the beginning of the test. (Refer to fig. 4-11.)

The switchbox is used either to switch the egt indicator into the circuit or to switch the temperature indication of the engine thermocouple harness to the jetcal potentiometer. However, temperature readings from the aircraft thermocouple harness can be made by connecting the check cable (with or without adapter) to the engine junction box. (See fig. 4-12.) The aircraft egt indicator must be used when the engine is started to be able to detect a hot start.

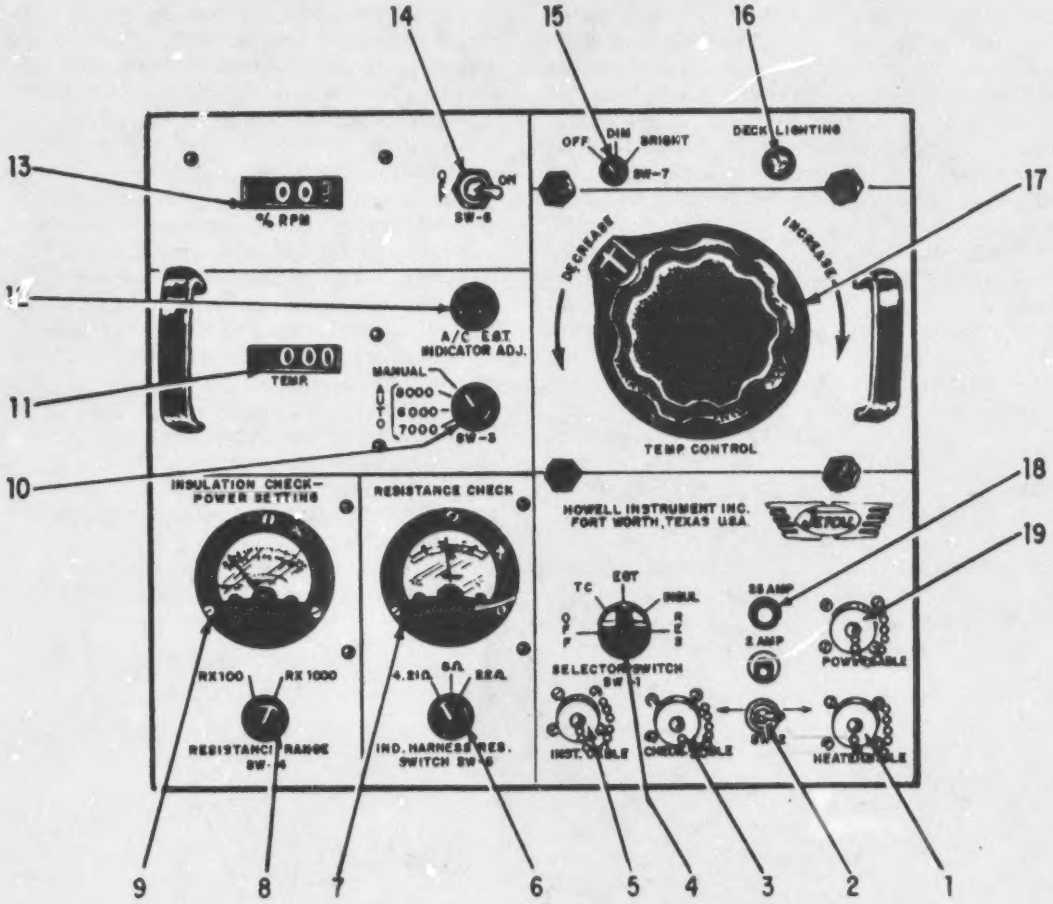
The engine is started and brought to speed in accordance with applicable technical instructions. During tabbing or nozzle scheduling procedures, all engine speed readings are made on the rpm check in the jetcal analyzer and engine temperature readings are made on the jetcal potentiometer. This is necessary because engine temperature and speed must be accurately read during engine tabbing to assure the operator that the engine is operating at optimum engine conditions as stated in applicable technical publications.

On engines with fixed nozzle areas, running at the rpm specified in applicable technical instructions, temperature readings are made on the potentiometer in the jetcal analyzer. If the



AD.225

Figure 4-12.—Check cable connected to engine junction box.



AD.352

1. Heater cable receptacle.
2. Heater-check cable switch SW-2.
3. Check cable receptacle.
4. Selector switch SW-1.
5. Instrument cable receptacle.
6. Ind. harness res. switch SW-5.
7. Resistance check meter.
8. Reistance range switch SW-4.
9. Insulation check-power setting meter.
10. Auto-manual switch SW-3.
11. Autotemp indicator.
12. A/C E.G.T. indicator adj.
13. Autotak indicator.
14. On-Off autotak switch SW-6.
15. Deck lighting switch SW-7.
16. Deck lighting receptacle.
17. Temperature control.
18. Fuses.
19. Power cable receptacle.

Figure 4-13.—Instrument compartment, BH109C jetcal analyzer.

temperature reading is not within the tolerances stated in applicable instructions, the engine is stopped and tabs are added or removed as required. The engine is run up and rpm and temperature readings are again taken to make sure that the tabs added or removed bring the tailpipe temperature within tolerance.

On engines with automatic controls, artificial heat can be applied to the thermocouple system before engine runup and initial adjustments can be made on both mechanical linkage and the control systems. During engine runup, rpm and temperature readings are made on the jetcal analyzer while final adustments are made on the control system.

Upon completion of the check, the egt system will have an accuracy of plus or minus 4° C at test temperature, which is usually the maximum operating temperature of the engine.

JETCAL ANALYZER MODEL BH109C

The BH109C jetcal analyzer was developed for shipboard use and is found primarily on aircraft carriers.

The complete analyzer consists of two cases. The smaller case contains check circuits similar to those found in other model jetcal analyzers. The second case contains heater probes, cables, adapters, and a temperature gradient test kit, where applicable. The jetcal analyzer operates on 115 (±10) volts, 40 (± 20) hertz, a-c power in environmental temperature ranging from -20° C (-4° F) to+55° C (131° F). A power frequency protection circuit is incorporated in the analyzer. This circuit prevents permanent damage to the jetcal analyzer through the application of improper power (60 hertz vise 400 hertz).

Basic differences between model BH109C and BH112J jetcal analyzers are the BH109C digital readout, servo operated, null balance temperature, and rpm measuring circuits. These circuits eliminate the necessity of adjusting galvanometers either electrically or mechanically and offer an additional advantage of continuous information presentation during test operations. In addition, circuitry for automatically stabilizing heater probe temperature is provided.

Figures 4-5 and 4-13 illustrate the visual differences in the BH112J and BH109C jetcal analyzers.

CHAPTER 5

FUEL SYSTEM MAINTENANCE

Fuel system maintenance is the responsibility of more than one work center. For instance, the AD must remove and install bladder and self-sealing fuel cells, and personnel of the AM rating perform the repairs on these cells. External tanks (drop tanks) are normally removed and installed by the AO rating, while hookup, check, and test of drop tanks are the responsibility of the AD. Bomb bay tanks, such as installed in the RA-5C, are removed and installed by the AD's and repairs to these tanks are performed by personnel of the AM rating. Therefore, in order to properly maintain that portion of the aircraft fuel system pertaining to the AD rating, the AD must be familiar with the aircraft fuel system as well as the engine fuel system. The following paragraphs cover a typical (A-7E) aircraft fuel system and principle of operation.

AIRCRAFT FUEL SYSTEM

The fuel system stores and delivers fuel under pressure to the engine and includes complete air refueling capabilities. The internal fuel system arrangement consists of the main and transfer fuel system and the air refueling system. The external fuel system arrangement consists of external tanks with mounting provision under the wings. Refer to figure 5-1 during study of this section.

COMPONENTS

All main fuel is contained inside the aircraft in the wing tank and six fuselage tanks (left and right forward tanks, left and right midtanks, an aft tank, and a sump tank). Fuselage fuel tanks contain selfsealing and bladder type fuel cells. These cells have a total capacity of 1,496 gallons. The external fuel system consists of four Aero 1-D auxiliary tanks mounted on pylons at wing stations 1, 3, 6, and 8. These tanks have a capacity of 1,200 gallons total.

Fuselage Fuel Cells

LEFT AND RIGHT FORWARD TANKS/CELLS.—The left and right foward tanks/cells are of the bladder type construction. Each cell has a total capacity of 91 gallons. Fuel from these tanks transfers to the sump tank by gravity flow.

THE LEFT AND RIGHT MIDTANKS.—The left and right midtanks are also of the bladder type construction. Each cell has a total capacity of 77 gallons. Fuel from the midtanks transfers to the sump tank by gravity flow.

AFT TANK.—The aft tank is of the bladder type construction and the lower part (approximately 120 gallons) is self-sealing. The total capacity of the aft tank is 326 gallons. Fuel is transferred to the sump tank by means of an ejector pump (explained later).

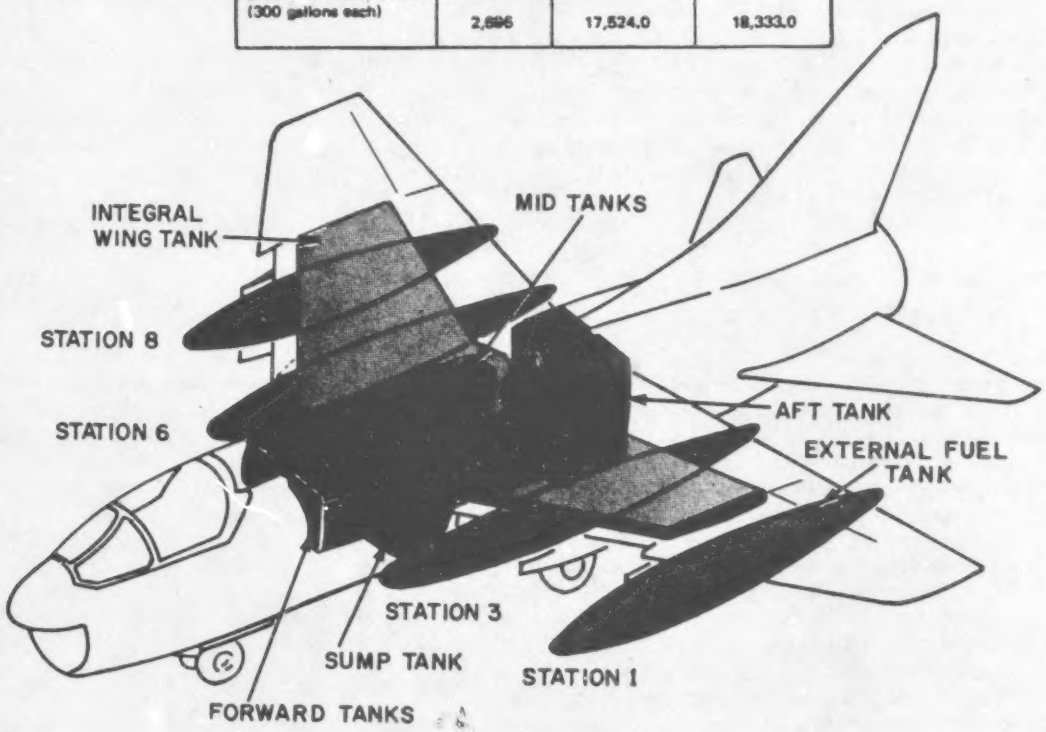
SUMP TANK.—The sump tank is a self-sealing constructed tank. The total capacity of the sump tank is 76 gallons. There is a check valve in the line from the aft tank to sump tank, which prevents reverse flow from the sump and/or loss of fuel if the line were ruptured. Fuel from the sump tank is picked up by the aircraft boost pump and delivered to the engine-driven fuel pump. The engine-driven fuel pump delivers fuel to the fuel control and the motive flow fuel system (ejector pumps).

Wing Fuel Cell

The wing integral fuel tank is formed by the wing center section main structure. Grooves form a leakproof seal when filled with a special sealant. The total capacity of the wing tank is 758 gallons. There are two ejector pumps in the wing tanks which enable transfer of fuel directly to the sump tank.

USABLE FUEL – GROUND ATTITUDE

TANK	GALLONS	JP-4(6.5 lb/gal.) POUNDS	JP-5(6.8 lb/gal.) POUNDS
R/H FWD	91	591.5	618.8
L/H FWD	91	591.5	618.8
R/H MID	77	500.5	523.6
L/H MID	77	500.5	523.6
AFT	326	2,119.0	2,216.8
Sump	76	494.0	519.0
Wing	758	4,927.0	5,154.4
Total	1,496	9,724.0	10,173.0
(4) Aero 1-D, D-76[illegible] Model 31-300 (300 gallons each)	1,200	7,800.0	8,160.0
	2,696	17,524.0	18,333.0



AD. 353

Figure 5-1.—A-7 aircraft fuel tank locations and capacities.

External Tanks

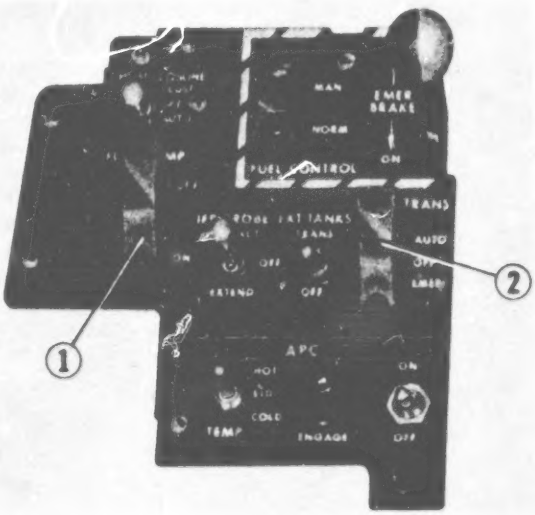
The external fuel system provides the aircraft with additional fuel storage and transfer capabilities. The system consists of external fuel tanks (Aero 1-D, 300-gallon capacity each), which can be mounted on pylons at wing stations 1, 3, 6, and 8, and may include a model D-704 tanker store for in-flight (buddy) fuel transfer. The tanker store may be installed on wing station 1 or 8 in place of the Aero 1-D external tank.

Fuel from the external tanks may be transferred directly into the fuselage for internal use by the aircraft. If the aircraft is equipped with a model D-704 tanker store, fuel may be transferred in flight to a receiving aircraft.

OPERATION

Sump and transfer ejectors (ejector pumps) are located in the wing tanks and the aft fuselage tank. There is a dual inlet ejector pump located in the sump tank. Operation of the ejector pumps requires the engine to be running. Cranking the engine for starting initiates operation of the fuel feed system by driving the centrifugal flow boost pump. A portion of the fuel flow from the boost pump is fed back to the inlet of the dual inlet ejector pump in the sump tank. the sump mounted ejector pump maintains a positive inlet pressure to the engine driven fuel pump. The engine fuel pump in turn supplies fuel to the fuel control and also supplies motive flow to the ejectors during operation of the engine. The transfer ejector pumps contain no moving parts and operate when supplied with high-pressure fuel from the engine pump. The high-pressure fuel, or motive flow, discharges through the ejector nozzle at high velocity and mixes with the low-pressure tank fuel entering through the inlet port of the ejector. The mixing of the high velocity motive flow with the tank fuel causes a pressure increase across the ejector. The discharge pressure of the ejector is sufficient to keep the sump tank full and slightly pressurized at all times. The ejectors are installed at low points in the tanks, assuring positive transfer of all available fuel from the tanks.

Operation of the main and transfer fuel system requires running of the engine to provide motive flow, as mentioned previously. Depending on the position of the two transfer selector valves, fuel will be transferred from the wing integral tank or the aft fuselage tank to the sump tank. Fuel transfer to the sump tank is normally sequenced automatically either from the wing and fuselage tanks (wing fuel transfer switch in AUTO) or from the fuselage tanks alone (switch in OFF). Emergency transfer of wing fuel is obtained by pressurizing the wing tank with engine bleed air (wing fuel transfer switch in EMER). Refer to figure 5-2.



AD. 354

1. Fuel dump switch (fuel dump).
   ON or DUMP—Opens shutoff valves to dump wing tank fuel overboard. Pressurizes wing tank and prevents transfer from wing and external tanks during dumping.
   OFF—Closes shutoff valves to stop fuel dumping and wing tank pressurization.
2. Wing fuel transfer switch (wing trans).
   AUTO—Actuates fuel transfer selector valves to provide ejector pump motive flow for automatic transfer of fuel.
   EMER—Opens air pressure regulator to provide regulated engine bleed air to pressurize wing tank for emergency transfer of wing fuel.
   OFF—Actuates wing or bypass fuel transfer selector valve to provide ejector pump motive flow to aft fuselage tank or to sump tank.

Figure 5-2.—Fuel system control panel.

Dumping of fuel from the wing integral tanks is accomplished by placing fuel dump switch to DUMP. This will prevent transfer from the wing and external tanks during dumping. When the dump switch is placed in the DUMP position, the dump valves, located in the trailing edge of the wing, open and the wing tank is pressurized, causing fuel to dump through the dump valves. Refer to figure 5-2.

Transfer from the auxiliary tanks (Aero 1-D) into the fuselage tanks is accomplished by placing the External Tanks Switch (left console) in TRANS. With the switch in TRANS, electrical power is removed from the solenoid-operated air selector valve, causing the valve to open. This permits engine bleed air to flow through the air pressure regulator, where it is reduced to approximately 30 psi, into the auxiliary tanks. Air pressure in the tanks forces fuel past the flapper in the pylon-mounted fueling valves into the fuel transfer lines. If the fuselage tanks become full, fuel flows into the wing tank from the aft and forward tanks. If the wing fuel level reaches the float valves in the top of the wing tank, the fueling pressure shutoff valve will close, and transfer from auxiliary tanks will stop. Transfer will resume when fuel drops below the float valves. As each tank empties, its pylon-mounted fueling valve closes to prevent airflow from entering the fuel system.

Dumping fuel from the auxiliary tanks may be accomplished in two ways if tanker store model D-704 is not installed. The first, in an emergency, is by jettisoning the external tanks. This is done by utilizing the weapons release controls. The second is by dumping the fuel from the wing tank and then transferring external fuel to wing tank. The dump and transfer cycle must be repeated until all fuel is expelled from the external tank. Installation of a tanker store, model D-704, provides a third method of dumping fuel from the auxiliary tanks. The model D-704 has a dump valve installed in the bottom of the tank. By transferring fuel from the auxiliary tanks to the tanker store, fuel may be dumped through the tanker store dump valve.

The main fuel system may be fueled by gravity or pressure. Gravity fueling is accomplished through one fueling receptacle on the wing center section and one fueling receptacle on top of the fuselage midsection. Pressure fueling is accomplished through the fueling manifold adapter in the left-hand main gear well. Electrical power is not required, and the location of the adapter permits fueling with the engine running without danger to personnel.

Auxiliary tank fueling may be accomplished through the aircraft pressure fueling adapter or gravity fueled through a receptacle on the forward top side of each tank. Pressure fueling of the Aero 1-D tanks requires application of external electrical power to open the solenoid-actuated fueling shutoff valves in the pylons. Placing the external tank ground refueling switch, located near the pressure fueling manifold adapter in the left-hand main gear well, in REFUEL energizes the solenoids on the valves to open the valves and initiates fueling of the tanks. Shutoff valves in each tank are controlled by a float switch, and as the tank becomes full, the float switch closes the valve.

FUEL CELL MAINTENANCE

Included among the various types of internal fuel cells used in naval aircraft are bladder type cells, self-sealing cells, and integral cells. Bladder type cells and self-sealing type cells are constructed of rubber and fabric and are removable from the aircraft. Integral cells form a part of the aircraft structure and are therefore not removable. If trouble develops within an integral cell itself, AMS personnel will handle the repairs.

Since the ADJ is concerned with removal, installation, and handling of bladder and self-sealing fuel cells, it is imperative that he be familiar with the construction features of these cells and have a clear understanding of the removal, installation, and handling procedures for each type. The ADJ should also know the methods used to identify metal particles found in fuel systems and oil systems.

During the process of removal and installation of a fuel cell, the fuel cell and aircraft will be open to tools, parts, and foreign objects. Check the cell and aircraft structure before installing a new or repaired fuel cell and, before completing an installation, account for all tools and spare parts. It would take only a small inexpensive part or tool left in a fuel cell to cause millions of dollars in damage and possible loss of life. After fueling a newly installed fuel cell, fuel drains, aircraft fuel filters, and engine fuel filters must be checked carefully for foreign matter and metal particles.

IDENTIFICATION OF METAL PARTICLES

When particles of metal are found in fuel cells, lines, and filters, as well as oil screens, they may be either magnesium, steel, cadmium, tin, aluminum, silver, or bronze. In some cases, the type of metal may be determined by the color and the hardness of the pieces. When the particles cannot be positively identified by visual inspection and the knowledge of the type of metal deposits is desired as an aid to troubleshooting, a few simple tests will determine the kind of metal present.

The following equipment and chemicals are required to make the few simple tests: A source of open flame, a permanent magnet, 2 ounces of water, 10 percent ammonium nitrate, an electric soldering iron, and 2 ounces each of hydrochloric acid (50 percent by volume) and concentrated nitric acid. CAUTION: Use extreme care when handling the acids.

For best results, the following test procedures are recommended for determining the type of unknown metal particles:

1. Magnesium. A simple test for magnesium particles is burning. Magnesium will burn with a bright white flash. CAUTION: Never attempt to burn more than a few particles of metal suspected of being magnesium. Magnesium powder or dust is explosive.

2. Steel. The steel particles can be isolated by using a permanent magnet. Steel or iron is attracted by a magnet.

3. Cadmium. Use a water solution of ammonium nitrate. Place the metal particles in the solution. If all or any of the particles dissolve in this solution, they are cadmium. After this test, rinse and dry any remaining particles.

4. Tin. Tin particles can be distinguished by their low melting point. Use a clean soldering iron, heated to 260° C (500° F) and tinned with 50-50 solder (50 percent tin and 50 percent lead). A tin particle dropped on the soldering iron will melt and fuse with the solder.

5. Aluminum. When a particle of aluminum is placed in hydrochloric acid (50 percent by volume), it will fizz with a rapid emission of gas bubbles and gradually disintegrate and form a black residue (aluminum chloride). Silver and bronze are not noticeably attacked by hydrochloric acid.

6. Silver. When a silver particle placed in nitric acid, it reacts rather slowly, producing a whitish fog in the acid.

7. Bronze. When a bronze (or copper) particle is placed in nitric acid, a bright green cloud is produced.

SELF-SEALING FUEL CELLS

A self-sealing cell is a fuel container which automatically seals holes or injuries caused during combat operations. A self-sealing cell is not bulletproof, but is merely puncture sealing. As the bullet passes through the cell wall into the cell, the sealant springs together quickly and closes the hole. At this time some of the fuel in the tank comes in contact with the sealant and makes it swell, completing the seal. In this application, science has used the natural stickiness of rubber and the basic conflict of rubber and petroleum to seal the hole. This sealing action reduces the fire hazard brought about by leaking fuel or oil and keeps the aircraft's fuel or oil intact so that the aircraft may continue operating and return to its base.

There are several different types of self-sealing cells currently used in naval aircraft. The most commonly used types are the standard six-ply cell, the combination bladder and self-sealing cell, and the nonmetallic plioform cell.

The bladder and self-sealing cell is the most common type.

The combination bladder and self-sealing cell is made up of two parts. One part is made of bladder type rubber, and the other part is made of six-ply self-sealing construction. This type cell is also semiflexible.

The nonmetallic plioform cell is of six-ply construction with additional supporting layers. The addition of the supporting layers makes this type cell nonflexible.

BLADDER TYPE FUEL CELLS

Bladder type cells are used when self-sealing properties are not required. These cells are usually made of very thin gage material in order to give minimum possible weight. They require complete support from a smooth cavity.

Bladder type cells are fabricated in the same manner as self-sealing cells in that they have a liner, nylon barrier, and a retainer ply. The sealant layers are omitted. All three plies are placed on the building form as one material in this order—liner, barrier, and retainer.

The liner is made of Buna N rubber, the barrier is nylon, and the retainer is a special fabric impregnated with Buna N rubber. The outside is finished with colored Buna N-Vinylite lacquer.

The major fittings are similar to those used in self-sealing fuel cells except that they have only one flange on the inside (liner side). The cell is made slightly larger than the cavity of the aircraft so the weight of internal pressure of the fuel is borne by the aicraft structure.

REMOVAL AND INSTALLATION

Most fuel cell damage occurs during the removal and installation process. The correct procedure to be used varies for each type of aircraft; therefore, reference should always be made to the Maintenance Instructions Manual for the aircraft concerned. There are, however, some general removal and installation procedures, as described in the following paragraphs.

Removal Procedure

The steps outlined below are generally followed when removing a fuel cell from an aircraft.

Defueling of the fuel cell is the first step and should be conducted in a designated area. Check to make certain that all the aircraft's electrical switches are in the OFF position. Ground the aircraft and container by approved methods. If no means of grounding is available attach a copper wire to the aircraft structure and secure the other end to a metal stake or pipe driven into the earth approximately 4 feet.

Make certain that firefighting equipment is on hand and in the proper working order with qualified personnel for its operation. Completely drain the fuel from the cell.

Purge the fuel cell to remove residual fuel, and explosive and toxic fumes. The use of air for purging is the most efficient and effective means of removing the explosive and toxic fumes present in empty fuel cells. Carbon dioxide may also be used for temporary displacement of explosive mixtures from the interior of fuel cells.

CAUTION: Water should not be used as a purging agent, as it may cause failure of cell stiffeners and baffles.

The cell must be purged until all odors of fuel are removed, or tested with the explosion meter to a nonexplosive mixture content. The most thorough job of purging can be accomplished after the cell has been removed from the aircraft.

Remove any necessary parts of the structure or accessories to gain access to cells. When necessary to remove special equipment, such as radio or radar equipment, it should be removed by a technician from the shop concerned, whenever possible. The removal of stressed skin panels may make it necessary on some aircraft to jack or hoist certain sections to relieve strain and prevent possible structural damage.

Disconnect all fittings and lines leading to the cells as required. Failure to do this may result in damaged fittings. The type of fittings to be disconnected from the cell depends upon the design of the fuel system in the aircraft. Access fittings on some types of cells may have to be removed. This is essential because other fittings may have to be removed from inside the fuel cell.

Tape or protect sharp edges and corners of all cavity openings to eliminate chafing.

If necessary, collapse the cell and strap it in a folded position, being careful that the bends do not occur at any of the fittings. Cells which require collapsing should never be removed by any other method.

Carefully remove the cell, observing the following precautions:

1. Do not pull the cell by its fittings.
2. Carefully guide the protruding fittings past all obstructions.
3. If the cell binds while removing it do not force it. Stop to determine the cause of the trouble and remedy it before continuing. Sprinkle the cell with talc or other suitable powder if it becomes necessary to squeeze the cell around or between structural members.
4. Do not pry on rubber fittings or on the cell with sharp instruments; use large wooden paddles.

Handling Precautions

Always carry or haul fuel cells. The purpose of carrying or hauling fuel cells is to protect the outside (retainer ply) wall, which serves to support the shape of the cell and protect the self-sealing (sealant) layer underneath it from gasoline spillage. The cord construction and lacquer coating must be cautiously safeguarded.

Never jostle or carry cells around by their fittings. Such handling may distort or break the metallic ring around the fitting, causing complete failure of the fuel cell. Do not flex cold cells since this will crack the stiffened synthetic rubber. Cells exposed to cold temperature (below 65° F) should be warmed to room temperature before being handled excessively.

Remove cells from shipping containers carefully. Before removing, be sure to detach all carrier straps and hanger fittings. Sufficient manpower should be available to carefully remove the cell from its container.

Never leave a semicollapsible cell without its stiffeners or internal braces for a period beyond 30 minutes. A longer time under such treatment will cause the cell to assume a permanent set or remain partially collapsed.

NOTE: Bladder type fuel and oil cells and nylon pliocels are much more delicate than self-sealing cells and require extremely careful handling; otherwise the handling precautions are the same as for self-sealing cells.

Installation Procedure

The steps outlined below are generally followed when installing a fuel cell in an aircraft.

Check the cell to make certain that it is the proper one for the cavity. Tape all cell openings. Inspect the fuel cell cavity for cleanliness and loose bolts, nuts, etc.; and make certain there are no sharp metal or protruding edges which may damage the cell during or after the installation of the fuel cell. Tape or otherwise protect the edges of the fuel cell if necessary.

Apply talc or other suitable powder to the outer surface of the cell and the cell cavity, as desired, to make it easier to move the cell into position.

If necessary, collapse or fold the cell as required and secure it with webbed straps. The cell should be warmed to room temperature; and when applying straps place them and the buckles so they are easily accessible after the cell is installed.

Guide the fuel cell into the cavity, making sure it is installed in the right direction. Wooden paddles with rounded edges may be used to guide the cell into the cavity; never use tools with sharp edges or points. If any binding occurs, determine the trouble and remedy it before damage is caused to the fuel cell. Be very careful that protruding fittings are not damaged.

Remove straps if cell was collapsed; then check the interior of the cell to make certain that no tools or foreign materials were left inside.

Install and torque all fittings as required. Tighten and torque bolts in such a sequence that no undue stress will be placed at any one particular point. Lockwire all bolts and screws as necessary and attach all bonding wires.

NOTE: The use of any sealing compounds on rubber fuel cell fittings is prohibited. Sealing compounds may be used only on connections when the adjoining surfaces are metal.

Check the entire system for leaks. The air pressure method is recommended. Cells may be checked by filling with fuel; however, leaks may not occur for 24 hours when using this method.

Torque Requirements

One of the main causes of fuel leaks can be attributed to improper torquing of bolts used to secure fittings, door cover plates, and attachments. Overtorquing causes excessive rubber cold flow, warps fitting plates, and in some cases, breaks the metal inserts in fittings. Improper torquing sequence results in fuel leaks; therefore, it is important that a set sequence be followed. Prior to installation, check the proper technical instructions for torque sequences and techniques.

Testing

When a new or repaired fuel cell is installed in an aircraft, it should be tested for possible leaks before it is filled with fuel. The air pressure test is the best method of determining if any leaks exist. This test consists of applying air pressure to a sealed cell and checking for the existence of leaks with a mercury manometer.

CHAPTER 6

TURBOJET POWERPLANT TROUBLESHOOTING

Troubleshooting jet aircraft engines may be defined as the systematic and thorough analysis of the symptoms of engine malfunctioning. Proper troubleshooting determines the proper corrective steps to be taken. Generally speaking, whenever irregular ground or flight operating characteristics are observed in jet engines, the cause can be traced to improper maintenance and operation, or the malfunctioning of engine components.

Efficient maintenance of any mechanism invariably depends upon the familiarity which operating and maintenance personnel have with the mechanism. The turbojet engine offers no exceptions to this rule.

It is essential that Aviation Machinist's Mates know the engine as thoroughly as possible. They should know what it is designed to do and how if fulfills that function. They should be familiar with normal operating details of the engine, such as oil pressures, temperatures, and consumption; fuel pressures and flows or temperatures; and exhaust gas temperatures. All of these should be known for at least three engine operating conditions; idle, normal rated and military. In addition to these items, personnel should have a thorough understanding of the effect of local conditions on the engine, that is atmospheric temperature and pressure, inlet ducting and tailpipe influences, and fuel temperature.

If information of the type contained in this chapter is followed, it will be productive of the most efficient maintenance, that is, preventing trouble before it arises, by recognizing abnormalities of the equipment and tracing them to their sources and making corrections before damage is done. Frequently, several seemingly unrelated indications of malfunctioning will eventually be traced to a single source.

It is often unsafe to assume that the engine is completely out of danger when some obvious corrective measure has been taken. Do not be hasty in assuming any conclusions. Do not confuse the significance of cause and effect. For example, low oil pressure, in itself, is not trouble. It is only an indication that some malfunctioning exists, the true cause of which is the trouble.

The preceding point is stressed to emphasize the importance of tracing an abnormal indication to its source, rather than being satisfied that restoration to normal by some obvious adjustment, such as changing the oil pressure relief valve setting, is all that is required. Invariably, there is a reason for abnormal indication. Be sure you know what the reason is and that you have taken the proper corrective measures before signing out the engine for further service. Proper corrective measure means the use of time-proven methods, not makeshift FIXES. For example, if any accessory fails to perform according to its specification and no standard repair or adjustment is established to correct the condition, replace with a new part and turn in the offending part so that it can be properly corrected at overhaul or scrapped.

Defects resulting from careless engine operation often may be observed best during disassembly when the component is covered with oil or carbon (prior to the cleaning process). During disassembly, visually check all components for signs of scoring, galling, or burning. Look for mechanical defects, deposits of carbon, and caked or coagulated oil. Trace the cause of the defects encountered and take the necessary remedial measures.

USE OF DIAGRAMS, DRAWINGS, AND CHARTS IN TROUBLESHOOTING

Every aircraft maintenance department is plagued to a certain degree by repeating discrepancies. These discrepancies show up repeatedly on the same aircraft, even after being

signed off as having been corrected. Although there are many possible causes for repeat discrepancies, the most common is due to poor troubleshooting procedures.

Troubleshooting is the logical or deductive reasoning procedure used when determining what is causing a particular system malfunction. There are seven steps involved in troubleshooting. These are (1) conduct a visual inspection, (2) conduct an operational check, (3) classify the trouble, (4) isolate the trouble, (5) locate the trouble, (6) correct the trouble, and (7) conduct a final operational check to certify that the trouble has been corrected.

To prevent poor troubleshooting procedures the diligent use of the applicable Maintenance Instructions Manual is essential. The MIM for each aircraft generally provides troubleshooting aids that encompass the aforementioned seven steps. The various MIM's provide a variety of troubleshooting aids. Table 6-1 depicts two examples of formats for troubleshooting charts; other formats are shown in later chapters of this manual. These charts are organized in a definite sequence under each possible trouble, according to the probability of failure and ease of investigation. These charts supply the trouble, probable cause, and the remedy for some of the more common malfunctions which cause the system to become inoperative or uncontrollable. In order to obtain maximum value from these charts, they should be used systematically in accordance with the aircraft manufacturer's recommendations.

Table 6-1.—Samples of various troubleshooting charts.

Trouble	Possible cause	Suggested remedy
1. Transfer fuel quantity indicator inaccurate.	a. Malfunction in indicator or probes; electrical circuit malfunction.	a. Check electrical circuit (sections VI and IX).
	b. Indicator not calibrated correctly.	b. Check calibration (section VI).
2. Aft fuselage cells fail to transfer fuel.	a. Electrical circuits out.	a. Check electrical circuits (section IX).
	b. Transfer booster pump failure, or lines obstructed.	b. Replace pump or clear obstruction.
	c. Main fuel low level float valves failed.	c. Replace low level float valves.
	d. Pressure shutoff valve failed.	d. Replace PSO valve.
	e. Fueling manifold malfunction.	e. Replace manifold.
	f. Fuel transfer switch not in "FUEL TRANS" position.	f. Move switch to "FUEL TRANS" position.

1. Turbine inlet temperature OFF flag is visible during all operations.

Release clamp and remove temperature indicator from instrument panel. Disconnect electrical connector. Is 28 volts d.c. indicated between pins B and C of connector?

YES → Replace indicator (NavAir 01-45AAA-2-18).

NO ↓

Check wiring for continuity. Is continuity indicated?

NO → Replace or repair defective wiring.

The MIM's also contain diagrams and drawings for use in troubleshooting. Diagrams of the various electrical circuits, fuel systems, lubrication systems, etc., are very useful in isolating troubles. Cutaway drawings illustrate the internal construction of components, and exploded views show how the various parts of a component are put together. All of these various types of illustrations are important to the ADJ in troubleshooting.

For a review on interpretations of drawings and diagrams, refer to ADJ 3 & 2, NavPers 10341-B, chapter 7.

GROUND SAFETY PRECAUTIONS

Troubleshooting a turbojet engine normally requires the engine to be installed in an aircraft and operating. This broadens the danger area for the maintenance man doing the troubleshooting. Safe working conditions must be maintained at all times. Therefore, the ADJ must be familiar with and observe all safety precautions. The following paragraphs cover some of the ground safety precautions.

Operational readiness of a maximum number of aircraft is necessary if naval aviation is to successfully perform its mission. Keeping its aircraft in top operating condition is the principal function of naval aviation maintenance personnel, and an essential objective should be to perform maintenance work without injury to personnel and without damage to equipment or aircraft.

Aircraft maintenance is, to some extent, naturally hazardous due to the nature of the work, the equipment and tools involved, and the variety of materials required to perform many repairs and maintenance functions. Factors which can function to increase or decrease these hazards are (1) the experience levels and mental attitudes of assigned personnel and (2) the quality of supervision of the maintenance tasks. Thorough indoctrination of all personnel is the most important single step in maintaining safe working conditions.

The concept of aircraft maintenance safety should extend beyond concern for injury to personnel and damage to equipment and aircraft. Safe work habits go hand-in-hand with flying safety. Tools left in aircraft, improper torquing of fasteners, and poor housekeeping around aircraft can cause conditions which may claim the lives of flying personnel as well as cause strike damage to aircraft. Safety on the ground is equally as important as safety in the air.

A recent type commander letter states in part, "While the increased complexity of our modern aircraft is a factor, it is noted that a large number of maintenance-error-caused accidents and incidents are due, not to complexity of equipment, but to lack of supervision and technical knowledge. Many mistakes are simple ones in routine maintenance."

Safety in aircraft maintenance depends largely upon the supervisory personnel. The standards of quality which they establish are directly reflected in the quality of the aircraft maintenance. The primary duty of the senior petty officers is to supervise and instruct others rather than to become totally engrossed in actual production. Attempts to perform both functions invariably result in inadequate supervision and greater chance of error. Supervisors must exercise mature judgment when assigning personnel to maintenance jobs. Consideration must be given to each man's experience, training, and ability.

AIR INLET

The air inlet may develop enough suction to pull in hats, eyeglasses, loose clothing, and rags from pockets. All loose articles should be made secure or removed before one works around the engine. In some engines the suction is strong enough to pull a man up to, or partially into, the inlet. Needless to say, precautions must be taken to keep clear of the inlet. On some installations spring-loaded access doors are provided at the inlet to the engine. The spring-loaded doors present a pinch-point hazard and hands should be kept clear of the doors. If maintenance work is to be done, the doors should be removed.

EXHAUST

Test have indicated that the carbon monoxide content of the jet exhaust is low. However, other gases are present which have a disagreeable odor and are irritating. Exposure to the exhaust will usually cause watering or a burning sensation of the eyes. Less noticeable, but important, is the respiratory irritation which may be caused. For both of the above reasons, exposure should be avoided, particularly in confined spaces or pockets where the concentration of gases may build up.

Two other important hazards of the jet engine exhaust are the high temperature and high velocity of the exhaust gases from the tailpipe.

High temperatures are found up to several hundred feet from the tailpipe, depending on wind conditions. Closer to the aircraft these temperatures are high enough to deteriorate bituminous pavements; concrete aprons are suggested for runup areas. Quite frequently when a jet engine is being started, excess fuel accumulates in the tailpipe; when the fuel ignites, long flames are blown out of the tailpipe. The possibilities of this hazard should be watched by personnel and all flammable materials kept in the clear.

During military power, the high velocity of the exhaust gases may pick up and blow loose dirt, sizable rocks, sand, and debris a distance of several hundred feet. Therefore, due caution should be used in parking an aircraft for runup to avoid personnel injury and property or aircraft damages. A blast fence is recommended if jet engines are going to be used extensively where there is not clear space available for dissipation of the exhaust gas blast.

After engine operation no work or inspection should be done in the exhaust section for at least one-half hour (preferably longer). If work is necessary immediately, asbestos gloves must be worn.

Sometimes overlooked in a maintenance program are the considerations generally grouped under the term "human factors." These factors are important in that they determine if an individual is ready and physically able to do work safely and with quality. Supervisory personnel should be constantly aware of conditions such as general health, physical and mental fatigue, unit and individual morale, training and experience levels of personnel, and other conditions which can contribute in varying degrees to unsafe work. Not only is it important that proper tools and protective clothing and equipment be available, but maintenance supervisors must insure that these items are properly used on all occasions requiring their use. For example, the supervisor must insure that maintenance personnel engaged in turbojet powerplant troubleshooting wear approved sound attenuating devices when working in high noise areas. As will be pointed out later, maintenance personnel tend to become negligent in the wearing of such devices for various reasons.

It is a continuing duty of every person connected with aircraft maintenance to try to discover and eliminate unsafe work practices. Accidents caused by such practices may not take place until a later date and their severity cannot be predicted.

Areas of extreme danger around jet engines are air intake, engine exhaust, jet wake, and engine ignition. Engine noise factor, exhaust gas toxicity, and contact with jet fuels and lubricating oils are also important factors relative to safety precautions. These danger areas and safety items are discussed in the following paragraphs.

ENGINE IGNITION

Due to the high voltage required for turbojet engine igniter plugs, the ignition switch must be in the OFF position before removal or checking of any of the ignition system components. A sufficient period of time must elapse between the operation of the ignition system and the removal or checking of components to insure the complete dissipation of energy from the ignition system.

ENGINE NOISE

Modern turbojet engines produce noise capable of causing temporary as well as permanent loss of hearing. Even short exposures to extreme noise may result in damage to the eardrum and all personnel should use some means of protection. At a sound level of 100 decibels (db) or more, ear protection should be used. The use of approved sound attenuating devices is required for all personnel working in the vicinity of jet engines being turned up.

Noise can affect the ear mechanism in such a way as to cause unsteadiness or inability to walk or stand without reeling. If engines are to be serviced from stands or platforms, they should be equipped with protective railings to prevent falls.

Ear Protection and Noise Abatement Devices

There are at the present time three general methods of protecting the ear with devices that attenuate airborne noise:

1. Insert types. Plugs inserted into the ear canal.
2. Cushion or doughnut types. Objects which cover at least the entrance to the ear canal and often the entire outer ear.
3. Helment types. Fitted coverings for the major area of the head.

For adequate protection in some noise fields, a combination of these devices may be required—for example, near the tailpipe of any aircraft equipped with afterburners when the latter are in operation.

Ear protective devices block out or attenuate noise of high frequency more effectively than noise of low frequency and are relatively more effective in attenuating the noise of jet engines than of reciprocating engines.

Some persons cannot wear standard insert type earplugs because of the unusual size or shape of their ear canals or because of ear infections. These individuals must rely on over-the-ear type devices for sound protection.

Over-the-ear type protectors have advantages and disadvantages. In cold weather they keep the ears warm, but in hot weather they are uncomfortable and cause excessive perspiration. Frequently they are incompatible with personal equipment, such as eyeglasses, parkas, and hats.

The most common complaint against earplugs is that they are uncomfortable. Proper fitting by a flight surgeon or hospital corpsman can overcome this problem to a large extent. An earplug which is too small loses much of its value because even a slight leak greatly decreases the protection; one that is too large is uncomfortable.

A popular misconception about ear protective devices in general and earplugs in particular is that they interfere with hearing and understanding the spoken word. The opposite is true. At any time when the ambient noise level exceeds 85 or 90 db, speech of a given intensity can be perceived more clearly through ear protective devices than without them. Further, a louder signal can be used if desired and will be perceived without the distortion and discomfort so commonly experienced in very noisy situations. (Under conditions of extreme noise, however, signals cannot be distinguished with or without ear protective devices.)

Earplugs are particularly effective under flight conditions. They serve to attenuate the ambient noise in the cockpit to a greater degree than can be accomplished by the action of the headset alone. They further act to improve the clarity of the radio signals.

The pilot's protective helmet affords much protection from sound conducted both through the middle ear and directly through the skull while the simplest headset and/or earplugs are effective only against sound conducted through the middle ear.

Research and development of new and improved ear protective devices continue. Study of the noise problem in military aviation continues. In the meantime, the best precaution against hearing damage is wearing ear protective devices any time high intensity noise is encountered. Whenever anyone is required to be in an area where high intensity noises may be encountered, ear protective devices should become part of the uniform. The best earplugs and sound attenuating devices in the world will not suffice if they are stowed in a locker when the need for them arises.

LEADED FUELS

A turbojet engine which has operated with leaded fuel (gasoline containing tetraethyllead) may have yellow residue on parts exposed to the exhaust gases. These deposits may cause lead poisoning if inhaled or swallowed. Parts covered with the yellow residue should be handled with caution. Be sure to clean parts showing yellow residue before reworking them; however, protect open cuts and your eyes, nose, and mouth against entry of any of the material from these deposits when performing the cleaning operation.

JET FUELS

Jet fuels have a low flashpoint and the same precautions that govern gasoline handling should be followed. The same possibility of the fuel easily being ignited exists, and safety measures are in order.

All jet fuels have a desiccating effect and dry the skin. Caution should be used to avoid contact as much as possible. Protective skin creams should be used when contact cannot be avoided.

JET LUBRICATING OILS

Jet lubricating oils may have an irritating effect on the skin, and the same safety precautions as used with fuel should be followed. In the event the clothing becomes saturated with either fuel or oil, the clothing should be removed immediately and the exposed area bathed thoroughly with soap and water.

CLEANLINESS

Efficient operation of a turbojet engine is largely dependent upon the cleanliness of the various engine components. These components must be kept meticulously clean and free from corrosion or foreign matter. The area in which any adjustment, replacement, or repair is to be done should be kept as clean as possible. All tools and equipment should be free of rust, grease, metal shavings, and other foreign matter.

During assembly, do not remove the wrapping from any part until ready to install. Do not remove the masking tape, seals, or plastic plugs from any orifice, passage, or port until necessary.

POLLUTION CONTROL

When it first began to dawn on people that the environment was worsening, that blight was creeping across our land, that the air was polluted and the waters running with waste, the Navy took steps to lessen its contribution to all the varieties of pollution. In the face of this challenge, Navy training and education must be broadened to include knowledge of how we affect our environment; thus, the inclusion of Pollution Control in this chapter.

Environmental education is not only "conservation education." Nor is it the sum of the antipollution concerns that have recently captured the public imagination. An environmentally literate individual is one who understands that he is part of a system composed of people, culture, and his physical and natural surroundings. He knows that man's acts can change his relationships to this system. He appreciates the human ability to in some degree control, preserve, or to destroy the environment. He accepts responsibility for the condition of his environment. But that does not mean that he knows what to do about it. What follows in the rest of this material is the presentation of information that is one small first step in your environment-oriented education and training.

Air Pollution

Five main classes of pollutants are pumped into the air over the United States, totaling more than 200 million tons per year. Transportation—particularly the automobile—is the greatest source of air pollution. It accounts for 42 percent of all pollutants by weight. It produces major portions not only of carbon monoxide but of hydrocarbons and oxides of nitrogen.

CARBON MONOXIDE (C) is a colorless, odorless, poisonous gas, slightly lighter than air, that is produced by the incomplete burning of the carbon in fuels. Carbon monoxide emissions can be minimized by supplying enough air to insure more complete combustion. When this happens, carbon dioxide, CO_2, a natural constituent of the atmosphere, is produced instead of carbon monoxide.

Almost two-thirds of the carbon monoxide in the air we breathe comes from internal combustion engines, and the overwhelming bulk of that comes from gasoline-powered motor vehicles.

PARTICULATE MATTER includes particles of solid or liquid substances in a very wide range of sizes, from those that are visible as soot and smoke to particles too small to detect except under an electron microscope. Particulates may be so small that they remain in the air for long periods and can be transported great distances by the winds. They are produced primarily by stationary fuel combustion (31 percent) and industrial processes (27 percent). Forest fires and other miscellaneous sources account for 34 percent.

There are established techniques for controlling particulates from a boiler stack or from a waste air stream—among them are filtering, washing, centrifugal separation, and electrostatic precipitation. These work well for most of the particles, but complete removal, especially of the very finest particles, is technically and economically difficult.

SULFUR OXIDES (SO_x) are acrid, corrosive, poisonous gases produced when fuel containing sulfur is burned. Electric utilities and industrial plants are its principal producers since their most abundant fuels are coal and oil, which contain sulfur as an impurity. The burning of coal produces about 60 percent of all sulfur oxide emission, oil about 14 percent, and industrial processes that use sulfur, 22 percent. Most of the coal and oil is burned in electric power generation plants. About two-thirds of the Nation's sulfur oxides are emitted in urban areas, where industry and population are concentrated. Seven industrial states in the Northeast account for almost half of the national total of sulfur oxides. In rural areas, however, sulfur oxide sources may be large industrial plants, smelters, or power plants. Any one of these may throw out several hundred thousand tons of sulfur oxides in a year.

Government agencies and industry have sought to reduce sulfur oxide emissions in three ways: switching to low sulfur fuels (those with less than 1 percent sulfur), removing sulfur from fuels entirely, and removing sulfur oxides from the combustion gases.

HYDROCARBONS (HC), like carbon monoxide, represent unburned and wasted fuel. Unlike carbon monoxide, gaseous hydrocarbons at concentrations normally found in the atmosphere, are not toxic, but they are major pollutants

because of their role in forming photochemical smog. More than half the estimated 32 million tons of hydrocarbons produced each year comes from transportation sources, mainly gasoline-fueled vehicles. Another 27 percent comes from miscellaneous burning and 14 percent from industrial processes. About 60 percent is produced in urban areas, largely because there are more automobiles.

NITROGEN OXIDES (NO_X) are produced when fuel is burned at very high temperatures. Stationary combustion plants produce 49 percent of the nitrogen oxide emissions; transportation vehicles, 39 percent; and all other sources, 12 percent.

Internal combustion engines operate at very high temperatures, and so do efficient, large electric power and industrial boilers. Nitrogen that is ordinarily inert combines with oxygen in high temperature flames and tends to stay combined if the exhaust gases are cooled too quickly. The control of NO_X from stationary sources requires careful adjustment of flames and stack gas temperatures. Control of nitrogen oxides from automobiles is more difficult because reducing other pollutants can increase the output of NO_X.

Under the influence of sunlight, nitrogen oxides combine with gaseous hydrocarbons to form a complex variety of secondary pollutants called photochemical oxidants. These oxidants, together with solid and liquid particles in the air, make up what is commonly known as smog. The photochemical oxidant family of pollutants can cause eye and lung irritation, damage to vegetation, offensive odor, and thick haze.

Reducing sulfur discharges from ships has proven to be a difficult job. Starting in 1967, the Navy developed a new type of fuel oil called Navy distillate fuel. This fuel reduces smoke and sulfur dioxide emissions very significantly. It is a clean-burning fuel and we are engaged in an intensive program to convert all our conventionally powered, steam-driven ships to this new type of fuel. Currently, we have 13 ships burning it with another 70 ships to be converted in the next six months. All of our some 700 ships will be converted by the end of 1972.

Controlling Air Pollution

As mentioned earlier, the internal combustion engine in automobiles is a prime pollution offender. To control their offenses, the first standards were set under the 1965 Amendments to the Clean Air Act and applies to 1968 model vehicles. These standards required complete control of crankcase hydrocarbons and partial control of exhaust hydrocarbons and carbon monoxide. Briefly, here is what the Navy has done to reduce pollution from crankcase and exhaust emissions:

During the combustion process in a gasoline engine, gases seep past the piston rings into the crankcase. These gases are the result of burned and unburned fuel and oil in the combustion chamber. The seepage, called blowby, moving past the rings is the result of:

1. High combustion chamber pressures.
2. Necessary working clearance of piston rings in their grooves.
3. Normal ring shifting that sometimes lines up clearance gaps of two or more rings.

If blowby is not removed from the crankcase it condenses in the crankcase to form sludge and to cause oil dilution.

In 1963, the Positive Crankcase Ventilation (PCV) system was introduced on all newly manufactured cars. However, this system had been used on military vehicles long before this to combat sludge problems. The first systems used the OPEN PCV system. This system uses manifold vacuum for its vacuum source. Fresh air enters an open PCV system through a vented oil filler cap, mixes with the crankcase vapors in the crankcase, and is metered through a PCV valve into the intake manifold. Here it blends with the fuel air mixture being delivered by the carburetor to be burned in the combustion chamber.

Starting in 1968, all new cars and trucks have been equipped with the CLOSED PCV system. The closed PCV system is similar in operating principle to the open system except that fresh air enters the closed system from the clean air side of the air cleaner or a separate PCV breather filter on the inside periphery of the air cleaner.

Most open and closed systems normally use a PCV valve. However, some installations use a fixed orifice instead of a valve. In some instances, the metering orifice is in the oil filler cap. In these systems, the airflow in the PCV system is not regulated, but only restricted. This is referred to as the tube type ventilation system. Regulation of the air fuel ratio is accomplished through carburetion alone, since the orifice size is fixed and cannot be varied during operation.

The detailed operation of these systems is covered in the Third and Second Class Rate Training Manuals for AS and CM.

Excessive (visable) exhaust emissions are due primarily to incomplete combustion in the combustion chamber. The automobile manufacturers use different means to control these emissions and likewise use different general terms to identify their systems.

Air injection was the first step toward the control of exhaust emissions. This is commonly referred to as an AIR PUMP system. It was first used in 1966 and 1967 on some cars and, beginning in 1968, was rather widely used on many cars. The following is a trade description of the air pump as offered by some manufacturers.

The system consists of an air pump, air manifold, check valve, and diverter valve. Most pumps use a relief valve in the side of the pump housing which relieves the pressure built up in the pump if it exceeds a predetermined value.

In operation, compressed air from the pump is distributed through a manifold to the pipe extension or jet behind each exhaust valve. The injection of air at this point causes those unburned fuel and oil particles and other by-products of combustion to burn here right in the exhaust manifold as they leave the cylinder head rather than pass out to the atmosphere through the exhaust pipe.

The check valve prevents exhaust gases from entering the pump should pump or drive belt failure occur.

During deceleration the fuel air ratio is very rich in the area of the exhaust valve. If the air pump system were allowed to operate under this condition, backfiring conditions would result as soon as the fresh air from the pump mixed with overly rich vapor to produce a combustible mixture. A vacuum-operated diverter valve (bypass valve) prevents this by dumping air pump output into the atmosphere during the deceleration period. (Some installations divert the air pump output directly back to the air pump itself.)

In addition to or substituting for the air pump, most cars manufactured beginning in 1968 use modified carburetion (resulting in cleaner fuel air ratios), revised ignition timing and hotter thermostats.

Motor vehicle pollution is the product of a complex combustion system of engines, fuels, and fuel additives. Effective control, then, means dealing not only with engines and control devices but with the fuel itself and with fuel additives.

The key undesirable additive from an air pollution control view point is tetraethyl lead in gasoline. It accounts for a significant portion of the particulate pollution from automobiles. Some gasoline manufacturers are producing gasoline that is almost leadfree. However, some premium gasolines containing lead will still be needed for a number of years to meet the requirements of high compression engines in older cars.

Jet engines also contribute their share of pollutants to the air. Present Navy efforts toward reduction of air pollution by jet engines are being directed along two channels: (1) improvement of engines and (2) removal of particulate matter from engine test cell exhausts.

To date, the Navy has spent money on development of smokeless combustors and the retrofitting of new combustor cans in certain engines. Replacement of combustor cans in the TF-30-P-8 and J52-P-8 engines has been completed. More money and effort will be spent to develop acceptable designs and prototypes to eliminate smoke from the TF 41, TF 30-P-6, T56, J79 and J57 models.

New naval aircraft engines will be equipped with smokeless combustors. These are the F14, S3 and engines for new heavy-lift helicopters.

It is expected that, by 1976 or 1977, all naval combat aircraft will be equipped with smokeless combustors and will comply with regulations on visible emissions.

Studies have been made of several systems for controlling emissions from jet engine test cells. A system called a "nucleation scrubber" or wet scrubber facility seems promising. It is expected to remove 99 percent of the noxious gases from engine test cell emissions.

The Navy, with the cooperation of Pratt and Whitney, has carefully evaluated the use of fuel additives, including Ethyl "CI-2," both in engine test cells and in flight. Tests have indicated degradation of engine performance and in some cases compressor stalls, a very unacceptable condition. Use of this additive has also resulted in deposits of hard residues on surfaces of internal engine parts, significantly increasing maintenance.

Water Pollution

Several basic, biological, chemical, and physical processes affect the quality of water.

Organic wastes (natural products such as food, paper, human waste) decompose by bacterial action. Bacteria attack wastes dumped into

rivers and lakes, using up oxygen in the process. Fish and other aquatic life need oxygen. If the waste loads are so great that large amounts of oxygen are spent in their decomposition, certain types of fish can no longer live in that body of water. A pollution-resistant lower order of fish, such as carp, replace the original fish population. The amount of oxygen in a water body is therefore one of the best measures of its ecological health.

If all the oxygen is used, an anaerobic (without air) decomposition process is set in motion with a different mixture of bacteria. Rather than releasing carbon dioxide in the decomposition process, anaerobic decomposition releases methane or hydrogen sulfide. In these highly polluted situations, the river turns dark, and odors - like rotten eggs - penetrate the environment.

Heated water discharged into lakes and rivers often harms aquatic life. Heat accelerates biological and chemical processes, which reduce the ability of a body of water to retain dissolved oxygen and other dissolved gases. Increases in temperature often disrupt the reproduction cycles of fish. By hastening biological processes, heat accelerates the growth of aquatic plants—often algae. Finally, the temperature level determines the types of fish and other aquatic life that can live in any particular body of water. Taken together, these effects of excess heat operate to change the ecology of an area—sometimes drastically and rapidly.

One of the most serious water pollution problems is eutrophication—the "dying of lakes." All lakes go through a natural cycle of euthrophication, but normally it takes thousands of years. In the first stage lakes are deep and have little biological life. Lake Superior is a good example. Over time, nutrients and sediments are added; the lake becomes more biologically productive and shallower. This stage has been reached by Lake Ontario. As nutrients continue to be added, large algal blooms grow, fish populations change, and the lake begins to take on undesirable characteristics. Lake Erie is now in this stage. Over time, the lake becomes a swamp and finally a land area.

Man greatly accelerates this process of eutrophication when he adds nutrients to the water—detergents, waste food products, fertilizers, and human wastes. He has done this in Lake Erie and countless other lakes. Man's action can, in decades, cause changes that would take nature thousands of years.

Mentioned above are the harmful effects of polluted waters on the natural environment, but what about water pollution's effect on human health?

Epidemics of typhoid, dysentery, and salmonellosis borne by polluted water are no longer serious public health threats in the United States. However, to maintain adequate protection of the public from these and other pollution dangers, water must often be treated to high levels before it is drinkable. Beaches often must be closed and shellfish left unharvested and unmarketed. Inadequately disinfected municipal wastes, overflows from combined sewer systems, and runoff from animal feedlots often create high bacteria densities in local water supplies. Ships that are anchored far upstream can contribute to a high bacteria count in a community's water supply. The Navy is exploring the use of many devices and schemes to lessen the effect of waste discharges on water. Some of them are discussed in the following paragraphs.

Because there have been no constraints on the quality of effluent (nutrients, etc) in the past, optimum damage resistance and minimum cost design for Navy ships dictated a minimum penetration of watertight bulkheads and decks. This led to direct overboard discharge of all waste drains and soil drains into rivers, bays, estuaries, and the high seas at the nearest point of approach of the hull plating from the head or washrooms. Carriers, for example, have as many as 150 discharge hull penetrations.

The Water Quality Improvement Act of 1970, PL 91-224, dated 3 April 1970, stipulates that the environmental protection agency would set the sewage system effluent standards. This law also stipulates that existing ships including those under construction would have to be backfitted within five years after the sewage system effluent standards were promulgated. Ships constructed after this date must meet the standards within 2 years. The Environmental Protection Agency, (EPA) expects to publish these standards by July 1971.

The Navy has funded research and development on Marine sanitation devices. These are: (1) Aerobic Systems, (2) the Macerator-Chlorinator, (3) the Recirculation Flush-sludge Storage System, (4) 175 Man Fairbanks-Morse System, and (5) the 500 Man Fairbanks-Morse System.

Aerobic systems for shipboard use have not been successful and the Navy terminated this effort several years ago. Both the Coast Guard and the EPA also terminated further development

of these basically small extended aeration biological systems for shipboard use.

The Macerator-Chlorinator system merely grinds the solids into small particles and mixes the raw sewage with hypochlorite and some chemical reaction occurs to reduce biochemical oxygen demand (a measure of the amount of oxygen needed to decompose wastes) and most of the organisms are destroyed. This unit is simple to install and operate and is lowest in cost, weight and space problem. Until satisfactory second generation devices are available, the Navy is recommending that EPA consider this device for ships, boats, and service craft having personnel of up to 50.

The recirculation system uses water to circulate the solid sludge to a holding tank where the water is removed and the concentrated sludge is stored. This sytem is similar to that used on commercial aircraft. The water is treated by chemicals and is recirculated in the system. The concentrated sludge is cleaned out when the ship is at sea or is connected to a shore sewage line. It is simple, low cost and requires low space and weight for installation. However, holding capacity is limited and this places a constraint on ship operations. One manufacturer of a system of this type is developing an incinerator to burn the sludge.

With all this effort and time, the Navy has yet to develop what can be considered a system that has proven reliable, maintainable and safe. Obviously, ship sewage disposal is the most difficult Navy problem to solve. Currently, we have 24 different proposals under evaluation and are encountering problems of performance and equipment reliability. The Navy must be absolutely certain that a completely reliable system is available before we start installing equipment on 700 naval ships at a cost now estimated to exceed $300 million.

WATER POLLUTION BY OIL.—The Navy's problems are not those generally caused by massive oil spills—but by the pernicious small spills in harbors which are caused by leaks in systems; overflows through vent pipes on ships; fuel line parting during oil transfers and recovering operations; and human errors. Cleaning up those oil spills is time consuming, difficult, costly and often result in claims against the Government. Also, such spills create a serious fire hazard, are harmful to fish, shellfish and wild life; cause damage to watercraft; denies unrestricted use of bathing beaches and other private property; can contaminate water supply systems; and be aesthetically displeasing.

This oil spill problem became acute with the signing of "The Water Quality Improvement Act of 1970" where the Congress declared "That it is the policy of the United States that there should be no discharge of oil into or upon the navigable waters of the United States, adjoining shorelines, or into or upon the waters of the contiguous zone; i.e., except those quantities as determined by the President."

The President through his enforcement agency, the Environmental Protection Agency (EPA), has established regulations which prohibit oil spills which "cause a film or sheen upon or discoloration of the surface of the water of adjoining shorelines or cause a sludge or emulsion to be deposited beneath the surface of the water or upon adjoining shorelines."

The Navy's oil pollution abatement problem and solutions are being approached in several directions:

a. Preventative Measures: Fleet commanders, Sea Frontier commanders, and commandants have an active program to reevaluate existing operational procedures. Education, increasing training measures with relation to oil problems and better preventive maintenance techniques, both ashore and afloat, are contributing a marked reduction in oil spills.

b. Containment of Oil at Source: To this end the Navy is programming the procurement of thousands of feet of oil booms for containing oils close to the source of spill. The Naval Research Laboratory in Washington, D.C. is studying how to control and confine oil spills using surface films. There are a series of organic chemicals which form very thin surface films (monomolecular layers) capable of driving oil across a water surface, increasing the oil-layer thickness, and reducing its area of coverage. A thicker oil layer occupying a smaller water surface area simplifies any recovery operation. More importantly the surface films can be used to prevent spreading of an oil spill; chemical boom effect. The oil-control films are largely insoluble in both oil and water and spread into extremely thin layers, usually only one molecule thick. Consequently, small quantities can cover large water surface areas and provide oil control and confinement.

Current research is directed toward the selection of ideal materials for this application which are nontoxic and acceptable to the

Environmental Protection Agency for use in rivers, harbors and estuaries.

c. Removal or Recovery of Oil from Within the Containment Area: The Navy policy is to physically remove oil from waters and to restrict the use of chemical emulsifiers, dispersants, and sinking agents, primarily to incidents which reduce hazard to human life or where there is substantial hazard of fire to property. Realizing that oil spills will inevitably occur in spite of our best efforts, the Navy is establishing at each of its major naval ports an "in house" rapid response capability to clean up moderate oil spills emanating from naval vessels or shore facilities. At most naval facilities this capability will team up with contractors, other federal agencies or join into municipal or industrial oil removal coops. In an effort to provide adequate equipment to do the job, the Navy has embarked on a Joint Funded Demonstration project for an oil skimming device with the Environmental Protection Division. The skimmer employs the inverted weir principle which takes advantage of the buoyant properties of oil. The oil is carried under the skimmer device and is captured in a chamber, essentially water free, for removal to storage areas.

Another promising device consists of a rotating multidisc drum that looks somewhat like a harrow as it turns in the water. As the drum passes over the oil and water, the oil adheres to the rotating discs. A wiping device cleans the disc and sends the oil through a collection pipe to a storage area.

Oil Spill on the High Sea.—We are all familiar with the massive oil spill problem associated with the Torroy Canyon tanker casualty off the coast of England and the Olean Eagle off San Juan, Puerto Rico. These accidents have generated national and international concern over the technical and managerial aspects of the problem.

The primary responsibility for mobilizing personnel and material resources against such major hazards rests with U.S. Coast Guard, Department of Transportation and the FWQA, Department of Interior. However, the recognized capability of the Navy to operate widely and diversely in the sea environment, makes it natural for naval forces to be called upon to assist in these major oil pollution catastrophies.

The deliberate pollution of the high seas by petroleum and petroleum products is causing concern to all nations of the world. To this end the NATO Committee on the Challenges to Modern Society met in Brussels in November of last year to develop action resolutions to combat pollution of the sea by oil spills. As of now all ships, in particular tankers, are permitted to dump ballast and bilge water into the high seas. The committee developed Navy resolutions which will have a major impact on the operation of vessels on the high seas in the near future.

The President stated in his meassage to the Congress of 20 May 1970 that the threat of oil pollution from ships at sea and in harbors represented a growing danger to our marine environment and any remedy must deal with this problem on a global basis. To initiate impetus for effective international cooperation in alleviating the threat of oil spills on open waters, and to demonstrate the highest level of interest, the President appointed the Secretary of Transportation as Chairman of the U.S. Delegation represented at the November 1970 NATO Committee on Challenges of Modern Society (CCMS) Oil Spill Conference in Brussels. The Secretary of Transportation in his address to the Conference stated that "The United States...is fully committed to a priority national policy of improving and safeguarding environmental quality. Few problems in this field are so pressing or so readily evident as those posed by ocean oil pollution .. My government proposes that NATO nations resolve to achieve by mid-decade a complete halt to all intentional discharges of oil and oily wastes into the oceans by tankers and other vessels. This is a fundamental and major goal; it may involve steps such as improved ship design aimed at clean ballast operations and the development of adequate port facilities to receive waste, oily bilge and ballast waters." The nations of NATO adopted this position in slightly modified tone as one of their major goals. In order for the Navy to respond effectively to this formidable task requested by the Administration and to demonstrate continued Navy leadership in the field of pollution abatement, the Navy initiated a survey of existing Naval Shore Facilities and ships to determine where required:

1. The current capability and capacity for handling, processing, reclaiming and/or disposing of bilge and ballast oily wastes from U.S. Naval vessels which will be required by mid-decade.

2. Needed repairs and alterations in shore facilities and operating practices for the receipt, storage, issue and handling of petroleum products, to prevent leakage and accidental discharge to the environment.

3. Required repairs and alterations to Naval ship systems, equipment and procedures for storing and/or handling oily mixtures while underway to prevent discharge to the ocean environment.

Based on this effort the total requirements and costs to meet these new pollution abatement commitments will be integrated into a phased and orderly plan for early programming, budgeting, and implementation.

AXIAL-FLOW ENGINE

The term "axial-flow" is derived from the direction of the air mass as it progresses along the engine axis through the engine. Axial-flow design permits higher pressure ratios to be obtained and consequently the higher altitudes of operation required for today's aircraft. The small frontal area of the axial-flow engine allows greater speeds to be attained by greatly decreasing the aircraft drag. This type of engine permits greater fuel economy by increasing the engine efficiency over the centrifugal-flow design.

One typical axial-flow turbojet engine employs a split axial-flow compressor, eight-can annular combustion chambers, a 3-stage reaction turbine, and an afterburner equipped with a 2-position exhaust nozzle. The multistage axial-flow compressor consists of a 9-stage low-pressure unit and a 7-stage high-pressure unit. The low-pressure unit is connected by a through shaft to the second- and third-stage turbine wheels, and the high-pressure compressor unit is connected independently by a hollow shaft to the first-stage turbine wheel. (See fig. 6-1.)

The engine is composed of the compressor section, the combustion chamber and turbine section, the accessory section, and the afterburner section (See fig. 6-2.)

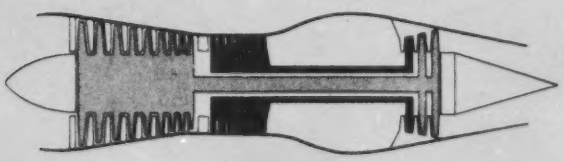


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Figure 6-1.—Split compressor.

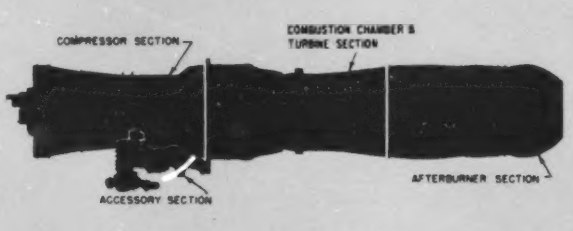

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Figure 6-2.—Axial-flow gas turbine engine sections.

COMPRESSOR SECTION

The compressor section of the axial-flow turbojet engine is subject to a variety of service troubles, especially damage from foreign matter passing through the compressor. Small pebbles, nuts, bolts, washers, etc., can cause severe damage to the compressor rotor blades and stator vanes. Damage severe enough to warrant complete overhaul of the engine could result from ingestion of foreign matter. Table 6-2 lists common troubles of typical axial-flow compressor.

COMBUSTION CHAMBER AND TURBINE SECTION

Figure 6-3 illustrates the type of combustion and turbine section used on the J57 engine. Although high temperature take place in the combustion and turbine section, few major service troubles are encountered when maximum temperature and maximum rpm limits are closely observed and adhered to. Hot starts, overtemperatures, and exceeding maximum rpm will readily cause extensive service troubles in the combustion and turbine section. Service troubles common to the combustion and turbine section of an axial-flow engine are listed in tables 6-3 and 6-4.

AFTERBURNER SECTION

Figure 6-4 illustrates a type of afterburner section used on an axial-flow gas turbine engine. Although simply constructed, the afterburner section requires constant observation. Generally, afterburner use is of short duration, but during use it is subjected to consistently high

Table 6-2.—Axial flow compressor troubleshooting chart.

Troubles	Probable causes and remedies
Nicks, dents, and cracks on compressor rotor blades, compressor stator vanes. NOTE: Passage of some foreign objects can easily cause strike damage to the engine.	Passage of foreign matter. Assure that intake duct and operating area are always clean of foreign matter. Use protective screens. Cracks on compressor rotor blades and compressor stator vanes are also caused by operating stresses. Repair, replace, or reject damaged compressor blades and stator vanes in accordance with applicable technical instructions.
Rubbing noise in compressor---	Excessive blade root looseness (radial) causing tip of blade to rub against compressor housing. Blade stretch. Blades working out of compressor rotor in an axial direction and rubbing against stator vane assemblies. Warped compressor stator vane assemblies rubbing against compressor rotor. Excessive compressor rotor axial clearance. Reposition, replace, repair, or reject in accordance with applicable technical instructions.
Engine overspeed---	Malfunctioning fuel control. Improper rigging of fuel control linkage. High speed stop improperly set. Refer to applicable technical instructions concerning engine overspeed. Generally, when the maximum rpm specified by the manufacturer has been exceeded, the engine is sent to overhaul due to the high centrifugal loads imposed upon the compressor and other rotating parts.

temperatures. Common services troubles of afterburner sections are listed in table 6-5.

ACCESSORY SECTION

Location of the accessory section will vary on different models of axial-flow gas turbine engines. Figure 6-5 illustrates one type of axial-flow engine accessory section. Table 6-6 lists some of the common service troubles of the axial-flow engine accessory section.

AIR SYSTEM

It should be clearly understood that interrupting or obstructing the air as it moves through the engine will affect the entire operation of the engine. Entrance of foreign matter into the air system is the chief cause of service troubles pertaining to the air system. Once again the importance of preventing foreign matter from passing through the engine is emphasized. When foreign matter enters the axial-flow compressor, it generally causes dented, cracked, and torn or broken compressor rotor blades and compressor stator vane damage. The foreign matter and broken pieces, as they pass rearward, cause improper combustion, blockage of cooling air passages, and physical damage to the combustion section, turbine section, and afterburner section. Passage of large or small foreign matter through the engine can result in a fused, twisted mass of melted metal.

FUEL SYSTEM

The fuel system of the gas turbine engine begins at the engine-driven fuel pump and ends with delivery of fuel to the combustion chambers through fuel nozzles in the form of highly atomized spray.

Common service troubles of the fuel system before the engine-driven fuel pump are wrong

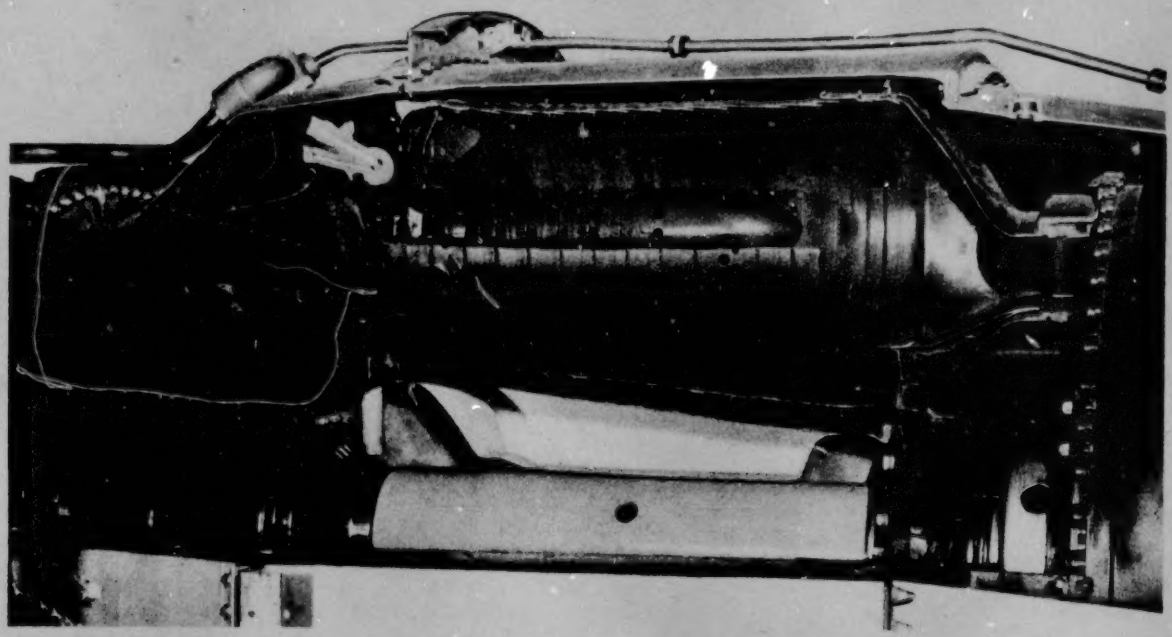

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Figure 6-3.—J57 combustion section cutaway view.

Table 6-3.—Axial-flow combustion section troubleshooting chart.

Troubles	Probable causes and remedies
Cracks, dents, distortion, warpage, hotspots, erosion, and deterioration in combustion chamber section.	Passage of foreign matter. Pieces breaking off combustion chamber and causing damage as they pass rearward. Improper torque. Malfunctioning fuel nozzles. Excessive heat concentration due to carbon accumulations. Normal wear. Certain types of cracking and burning deterioration resulting from thermal stresses may be found on new engines. NOTE: The majority of discrepancies occur in the early stages of operation, and further progression may be expected to proceed at a greatly reduced, if not negligible, rate. Always refer to applicable technical instructions to determine whether or not defective parts discovered can be repaired or continued in service, or whether the unit or part should be rejected.

Table 6-4.—Axial-flow turbine section troubleshooting chart.

Troubles	Probable causes and remedies
Cracks, dents, distortion, erosion, and localized overheating on turbine nozzle guide vanes.	Passage of foreign matter. Pieces breaking off combustion chamber. Improper torque of attaching bolts. Engine operating overtemperature. Malfunctioning fuel nozzles. Normal wear. Repair, replace, or reject in accordance with applicable technical instructions.
Cracks, dents, nicks, distortion, and warpage on turbine blades and turbine wheel or wheels. NOTE: Turbine blades and turbine wheels are also subject to blade or wheel growth (stretch) when excessive rotational or excessive temperatures are attained.	The above probable causes and remedies also apply here.
Localized overheating, warpage, and cracks on turbine case.	Malfunctioning fuel nozzles. Bowed, broken, or distorted turbine stator vanes. Improper torque of attaching bolts. Repair, replace, or reject in accordance with applicable technical instructions.

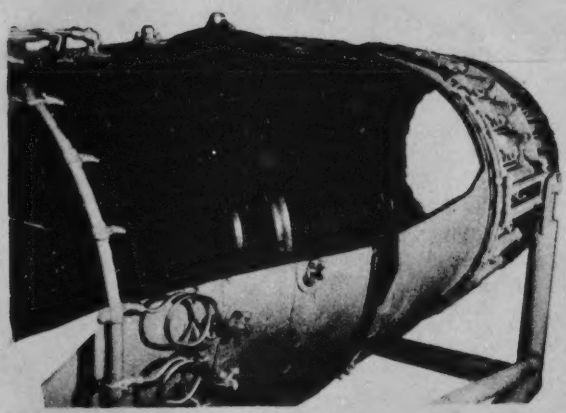

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Figure 6-4.—J57 afterburner cutaway view.

type fuel, water or other foreign matter in the fuel, defective fuel boost pumps, and clogged fuel filters. Needless to say, the remedial measures taken for the above service troubles are obvious.

LUBRICATION SYSTEM

Use of the proper grade of oil and cleanliness when replenishing the oil supply are absolute requirements to avoid unnecessary lubrication system troubles. This must be thoroughly emphasized to the men servicing the lubrication system. Gas turbine engines have few moving parts, but the speed at which the parts move, especially the rotor (generally between 8,000 and 12,000 rpm), requires constant lubrication to rotor bearings. Oil starvation for a short period of time can result in having to remove the engine for overhaul. Common service troubles of an axial-flow lubrication system are listed in table 6-7.

For years investigations have continued to be based on the concept that, if it were possible to identify and measure the wear metals present in engine lubricants, it would be possible to use

Table 6-5.—J57 afterburner troubleshooting chart.

Trouble	Probable Cause	Investigation	Remedy
Afterburning does not take place when throttle is placed in afterburner position.	Defective afterburner switch.	With throttle full forward and in afterburner position, check continuity between common and normally open terminals on afterburner switch.	Replace switch.
	No power to afterburner switch.	Check for voltage between afterburner fuel control lead and ground.	
	Defective solenoid on afterburner fuel control.	If the preceding checks indicate that power is available at solenoid, solenoid is defective.	Replace afterburner fuel control.
	Defective afterburner igniter.		Replace afterburner igniter.
	Afterburner emergency shutoff valve linkage out of adjustment.	Check linkage.	Adjust linkage.
	Igniter filter clogged.	Check filter.	Clean filter element.
Exhaust nozzle fails to open or close when afterburning is initiated or terminated.	Defective exhaust nozzle control.		Replace exhaust nozzle control.
	Misadjusted nozzle flaps.	Visually check operation of nozzle with engine running. Observe position of all nozzle flaps during transition from nonafterburning to afterburning operation.	Adjust nozzle linkage.
Turbine exhaust temperature, rpm, or engine pressure ratio deviate more than acceptable.	Defective afterburner fuel control.	If nozzle operates correctly and basic engine operation is satisfactory, afterburner fuel control is defective.	Replace afterburner fuel control.

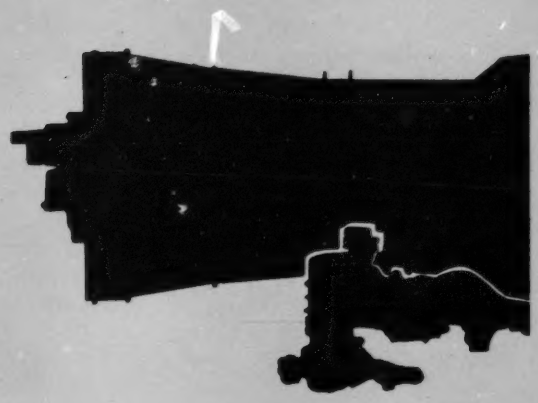

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Figure 6-5.—J57 accessory section.

the information as an aid in diagnosing engine condition. All of the Armed Forces have recently accepted the highly successful Spectrometric Oil Analysis Program (SOAP), pioneered and developed for military aviation by the Bureau of Aeronautics (Naval Air Systems Command) since 1955, as an effective and reliable maintenance tool in determining the condition of internal oil-wetted components of aircraft power-plants, transmissions, etc.

The monetary savings attributed to SOAP, while difficult to ascertain, have been estimated in the million of dollars. The Air Force Tactical Command has attributed a savings of $50 million to the use of SOAP over a 3-year period. The Army at Fort Rucker reported that the benefits obtained in 1966 exceeded $4 million. Although the Navy has not calculated its savings in dollars, the overall accuracy of prediction for the Oil Analysis Program was stated as follows: jet engines, 90 percent; reciprocating engines, 80 percent; transmissions and gear boxes, 92 percent. These impressive figures, coupled with immeasurable conservation of human life, illustrate some of the tangible benefits to be achieved through diligent application of the program.

The Spectrometric Oil Analysis Program is briefly discussed in the following paragraphs. Complete information on this program is contained in BuWeps Instruction 4730.8.

Spectrometric Oil Analysis

It is now standard practice for a physician to take a specimen of his patient's blood, and through an analysis of the proteins, salts, sugars, wastes, etc., obtain an excellent picture of the individual's health. Based on this analysis,

Table 6-6.—Axial-flow engine accessory section troubleshooting chart.

Troubles	Probable causes and remedies
Chafed, broken, or loose electrical leads.	Improper installation. Damaged during removal or installation of engine. Repair or replace in accordance with applicable technical instructions.
Cracks, dents, loose lines, corrosion, and evidence of leakage.	Hard landings. Improper torque. Improper safetying. Improper painting or preservation procedure. Missing or broken gaskets or O-rings. Repair or replace in accordance with applicable technical instructions.
Cracked, corroded, loose, or leaking flange-mounted accessories.	The above causes and remedies apply.

Table 6-7.—Axial-flow engine lubrication system troubleshooting chart.

Trouble	Probable cause	Investigation	Remedy
High oil temperature	Insufficient oil in tank.	Check oil level in tank.	Fill tank.
	Clogged oil strainer.	Remove and inspect oil strainer.	Clean or replace.
	Bearing failure	Check the oil and strainers for metal particles.	Remove the engine.
	Defective oil pump.	Check pump operation with a master gage.	Repair or replace oil pump.
Low oil temperature	Oil temperature gage not functioning properly.	Check oil temperature gage and sensing unit for accuracy.	Replace or repair oil temperature gage.
	Thermostatic valve in the fuel coolant oil cooler not functioning.	Remove and check the cooler for proper operation.	Replace the oil cooler.
High or low oil pressure	Oil pressure relief valve malfunctioning.	Check for free movement of relief valve.	Repair or replace, adjust valve if necessary.
	Main oil pump malfunction.		Replace main oil pump.
	Oil pressure gage not functioning properly.	Check oil pressure gage with master gage.	Replace oil pressure gage.
Excessive oil consumption	Oil leakage.	Visually inspect all external tubing and case parting flanges for oil leaks.	Tighten connectors. Replace seals or gaskets as necessary.
	Loose oil tank cap.		Tighten cap.
	Breather pressurizing valve not functioning properly.	Remove and check the valve for proper operation.	Replace breather pressurizing valve.
Excessive oil pressure	Defective oil pressure transmitter and/or indicator.	Replace instrument with one of known accuracy and recheck pressure.	Replace instrument.

Table 6-7.—Axial-flow engine lubrication system troubleshooting chart—Continued.

Trouble	Probable cause	Investigation	Remedy
Excessive oil pressure--Continued.	Misadjusted relief valve.	If pressure indicating system is satisfactory and engine operational check does not disclose any apparent malfunctioning, the relief valve can be adjusted.	Adjust relief valve.
	Relief valve stuck closed.	Check relief valve for freedom of movement.	Replace valve.
Low or fluctuating oil pressure	Insufficient oil supply.	Check oil level.	Service oil system.
	Clogged or dirty strainer.	Pull oil strainer.	Clean strainer.
	Relief valve adjusting screw backed off.	Check adjusting screw locknut.	Adjust relief valve and tighten locknut.

the physician can initiate preventive measures to relieve a potentially serious condition, or he may determine that immediate corrective measures, predicted upon the symptoms revealed in the analysis, are warranted. This is precisely the objective of the Oil Analysis Program: to determine the "health" of aircraft mechanical systems, such as turbojet, turboprop, and reciprocating engines, helicopter transmissions, gear boxes, constant speed drives, hydraulic systems, and oil- or fluid-wetted dynamic parts. The internal condition of an enclosed mechanical system can be evaluated by the spectrometric analysis of lubricating oil or fluid specimens properly extracted from the system.

The contact between moving components of any mechanical system is always accompanied by friction. Even though this friction is reduced by a thin film of oil, submicroscopic particles of metal do wear away and are carried suspended in the oil. The worn surfaces and the metal particles worn from those surfaces retain their identities as elements. Now, if the "rate of production" of each type of metal particle can be accurately measured and established as being normal or abnormal, then the "rate of wear" of the contacting surface can also be established as normal or abnormal. The chemical identification of the abnormally produced metal particles will provide pertinent clues as to the identity of the component suffering the abnormal wear.

When applied under controlled conditions, this technique will provide the following benefits:

1. An important diagnostic aid for the early detection of possible failure.
2. Reduction of overhaul and repair costs.
3. Valid maintenance quality control data.
4. Substantial reduction of in-flight failures.
5. Acceptance criteria for new equipment.
6. Valid data to assist in the extension or reduction of equipment replacement intervals.

7. Data on new systems undergoing research, development, test, and evaluation.

The validity of an oil sample extracted for the spectrometric analysis of wear-metal content is totally dependent upon whether the oil has circulated long enough to accumulate wear-metal concentrations that are truly representative of the oil throughout the system. BuWeps Instruction 4730.8 details procedures for implementation of the Spectrometric Oil Analysis Program and specifies intervals, techniques, and precautions pertinent to obtaining and forwarding valid samples.

NOTE: When a unit is introduced into the program, an Oil Analysis Program decal (fig. 6-6) must be applied to a conspicuous location on the unit and another decal applied to the front cover of the logbook as applicable. A decal must also be placed on shipping containers of these units when they are returned for overhaul. This decal may be obtained from the Supply Department, Naval Air Station, Pensacola, in packages of 100.

ELECTRICAL SYSTEM

The method of actuating the ignition switch is the responsibility of the airframe manufacturer, the manner in which this is accomplished will therefore vary, depending upon the particular aircraft installation.

The J79-GE-8 requires two ignition systems. The main ignition circuit is a high-energy circuit energized from the cockpit manually operated switch. The circuit furnishes the ignition for the air-fuel mixture in the combustion liners. (The main igniter plug is mounted in a boss on the outer combustion casing and projects into the number four combustion liner.) The afterburner ignition circuit is a low-energy circuit and is energized by a signal from the main fuel control when the throttle is moved to the afterburner range and engine speed is within limits.

When an axial-flow engine fails to light and the starting fuel flow is correct, one of the most probable causes is the igniter plug. The igniter plug can be checked by energizing the ignition system and listening for the firing of the igniter plug. A good plug will give 2 to 3 sharp cracking sounds per second. Poor plugs will sound weak or give no indication of firing. Once again it must be emphasized that the output voltage of the ignition unit is very dangerous. A sufficient period of time must elapse between the operation of the ignition system and the removal or checking of components to insure the complete dissipation of energy from the ignition system.

NOTE: Additional troubleshooting procedures for the J57 engine afterburner ignition system were presented in table 6-5 under the heading, "Afterburning does not take place when throttle is placed in afterburner position".

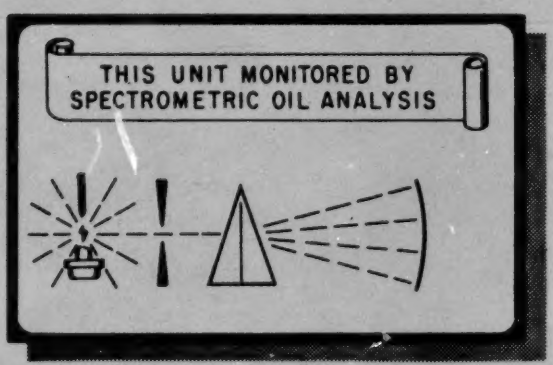

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Figure 6-6.—Spectrometric Oil Analysis Decal.

GENERAL TROUBLES

The isolating and correcting of engine troubles should be accomplished by comparing symptoms with probable causes. Begin with the most obvious and proceed to the less likely causes. Do not overlook flight reports as well as previous engine history in the effort to track down causes and remedy the difficulty. It must be kept in mind that a combination of several small maladjustments or malfunctions may contribute to make a complex difficulty. Table 6-8 enumerates the general conditions which may be encountered.

CORROSION

Metal corrosion is the deterioration of the metal by chemical or electrochemical attack. The deterioration can take place internally as well as on the surface. Corrosion can cause eventual structural failure if left unchecked. Therefore, corrosion cannot be overlooked as a possible cause of trouble when troubleshooting a turbojet engine.

Table 6-8.—Troubleshooting chart of axial-flow engine general troubles.

Trouble	Probable cause	Investigation	Remedy
Compressors fail to rotate during attempted start	Inadequate or no air supply to starter.	Air supply source.	Provide adequate air supply to starter.
	Internal rotating parts binding.	Check rotor for freedom of rotation.	Replace engine.
	Sheared starter jaw or sheared starter drive in N_2 gearbox.	Starter rotation.	Replace faulty components.
Engine fails to "light-off" when power lever is advanced to idle	Main power switch off.	Check power switch for "ON" position.	
	Defective ignition system.	Turn on system and listen for igniter plug operation.	Refer to IGNITION SYSTEM TROUBLESHOOTING.
	No fuel to engine.	Fuel shutoff lever not fully open.	Adjust linkage.
		Wrong grade of fuel or contaminated fuel.	Drain tanks and refill with the proper fuel.
		Obstructions in fuel pump inlet line or filter.	Clean lines and filter.
		Fuel tank boost pump inoperative.	Repair or replace boost pump.
		Obstructions in fuel tank vent lines.	Clean lines.
Engine "lights-off" but fails to accelerate to idle	Starter cut-out too low.	Check auxiliary power unit and/or starter.	Repair or replace.
	Inadequate air supply.	Air supply source.	Provide adequate air supply to starter.
	Loose or broken burner pressure sense line.	Check sense line for security or damage.	Tighten or replace sense line.
	Burner pressure limiter stuck open.		Replace fuel control.

Table 6-8.—Troubleshooting chart of axial-flow engine general troubles—Continued.

Trouble	Probable cause	Investigation	Remedy
Engine "lights-off" but fails to accelerate to idle--Continued	Fuel control acceleration schedule out of limits.		Replace fuel control.
	Fuel control linkage improperly rigged.	Angle of pointer at fuel control when power lever is in idle.	Correct rigging of linkage.
Failure of engine to decelerate properly	Fuel control rigging error.	Inspect linkage.	Adjust linkage.
	Malfunctioning fuel control		Replace fuel control.
Fluctuating rpm	Contaminated fuel.		Drain tanks and refill with proper fuel.
	Defective instrument and/or instrument circuits.	Check instrument for accuracy. Check the electrical circuits for abnormal resistance and continuity.	Repair or replace defective components.
	Compressor bleed valves malfunction.	Observe position of compressor bleed valves during start.	Clean the lines to the pressure ratio control. Check the valves for freedom of movement.
	Fuel tank vent obstructed.	Check for obstruction.	Clean lines.
	Clogged fuel filter.	Remove and inspect fuel filter.	Clean or replace.
Inability to obtain maximum fuel flow	Incorrect trim.	Check trim.	Replace fuel control if trim cannot be obtained.
	Incorrect travel of power lever linkage.	Power lever linkage for proper travel between the lever and fuel control.	Readjust or replace linkage.

Table 6-8.—Troubleshooting chart of axial-flow engine general troubles—Continued.

Trouble	Probable cause	Investigation	Remedy
Inability to obtain maximum fuel flow--Continued	Malfunctioning fuel control.	Check fuel flow through flowmeter.	Replace fuel control.
	Clogged fuel filters.	Remove and inspect the fuel filters.	Clean or replace.
Engine slow in accelerating	Defective fuel control.	Possible broken compressor inlet temperature capillary tube to fuel control.	Replace fuel control.
Hot start	Defective ignition.		Refer to IGNITION SYSTEM TROUBLESHOOTING.
	Insufficient cranking speed.	Auxiliary power unit and/or starter.	Repair or replace.
	Accumulation of fuel in the engine.	Check the drain valve on the combustion chamber case.	Remove excess fuel from engine and refer to FUEL SYSTEM TROUBLESHOOTING.
Low exhaust duct temperature	Improper trim.		Retrim.
	Malfunctioning fuel control.	Check for proper trim.	Replace the fuel control if trim speed cannot be attained.
	Defective thermocouple.	Check the thermocouple leads and instruments.	Repair or replace defective leads or instrument.
Engine roughness or vibration	Interference between turbine rotor inner air seals and the inner seal rings.	Check for scraping noise as engine slows down after closing the fuel pressurizing and dump valve.	Replace the engine.

Table 6-8.—Troubleshooting chart of axial-flow engine general troubles—Continued.

Trouble	Probable cause	Investigation	Remedy
Engine roughness or vibration--Continued	Main bearing failure.	Check the oil strainer for metal particles.	Replace the engine.
	Erratic fuel flow.		Replace fuel control.
	Combustion flame pattern incorrect.	Check for faulty or dirty fuel nozzles, collapsed or damaged combustion chambers.	Repair or replace nozzles or chambers.
High exhaust duct temperature	Engine over trimmed.		Retrim.
	Insufficient air.	Check the air intake for obstructions.	Remove obstructions.
	Defective thermocouple leads, or temperature gage.	Check the thermocouple leads and instruments.	Repair or replace thermocouple leads and instruments.

A thorough comprehension of the dangers of corrosion, the ability to recognize the various forms of corrosion, and the development of the skills necessary to cope with these dangers should be included in the objectives of every powerplants work center training program.

When troubleshooting a turbojet engine, the entire engine as well as all parts removed should be cleaned and inspected for evidence of corrosion.

NOTE: Types of corrosion are discussed in detail in ADJ 3 & 2, NavPers 10341-B, chapter 14.

IDENTIFICATION AND TREATMENT

When active corrosion is visually apparent, a specific and immediate program for identification and treatment is required. In general, any complete treatment involves the cleaning and stripping of the corroded area, the removal of as much of the corrosion products as practicable, the neutralization of any residual materials that may remain in pits and crevices, such restoration of protective surface treatment films as is practicable, and the earliest replacement of permanent protective coatings and paint finishes. Each particular type of corrosion has its own peculiarities and may require special treatment.

One of the most familiar types of corrosion is red iron rust, generally resulting from atmospheric oxidation of steel surfaces.

Some metal oxides protect the underlying base metal, but red rust is not a protective coating in any sense of the word. Its presence actually promotes additional attack by attracting moisture from the air and acting as a catalyst in causing additional corrosion to take place. As a result, all rust must be removed from steel surfaces if complete control of corrosive attack is to be realized. There is no effective inhibitor for its safe control on aircraft surfaces in the installed condition.

Rust first shows on boltheads, holddown nuts, and other unprotected aircraft hardware. Its presence in these areas is generally not dangerous and has no immediate effect on the

structural strength of any major components. However, it is indicative of a general lack of maintenance and possible serious attack in more critical areas. It is also a factor in the general appearance of the equipment. When paint failures occur or mechanical damage exposes highly stressed steel surfaces to the atmosphere, even the smallest amount of rusting is potentially dangerous in these areas and must be removed and controlled.

Magnesium attack is possibly the easiest type of corrosion to detect in its early stages, since magnesium corrosion products occupy several times the volume of the original magnesium metal destroyed. The beginnings of attack show as lifting of paint films and white spots on the magnesium surface, which very rapidly develop into snowlike mounds or even white whiskers. Reprotection involves the maximum removal of corrosion products, the partial restoration of surface coatings by chemical treatment, and a reapplication of protective coatings.

PREVENTION AND CONTROL

Prevention and control are powerful tools which can be used to effectively correct even the most difficult "built-in" corrosion problem. Such a program can be adjusted by the operating squadron to meet the severe environment of shipboard operations, and then decreased in scope when the aircraft is returned to the relatively mild conditions of an inland shore base. Much has been done to improve the corrosion resistance of military aircraft, including improvements in the selection and combination of materials of construction, in chemical surface treatments, in dissimilar metal insulation, and in protective paint finishes. All of these have been aimed at reducing maintenance effort as well as improving reliability. But in spite of refinements in design and construction corrosion and its control are a very real problem that requires a continuous maintenance program, particularly under marine operating conditions.

Methods

The methods of prevention and control, as related to corrosion control, include the following specific functions:

1. Adequate cleaning program.
2. Periodic lubrication.
3. Detailed inspection for corrosion and failure of protective systems.
4. Emergency treatment of corrosion as it occurs.
5. Early paint touchup of damaged areas.
6. Use of supplementary preservative coatings as necessary.
7. Adequate draining of internal cavities by maintaining drain holes free of obstructions.
8. Daily draining of fuel cell sumps to remove accumulated water and other foreign matter.
9. Daily wipe down of exposed critical surfaces.
10. Sealing of aircraft against water and salt spray during foul weather, and proper ventilation of the same aircraft on warm, sunny days.
11. Using all available protective covers on parked aircraft (wing roots, air intakes, jet exhausts).

In corrosion control work, the term "clean" means to do the best job possible, using the materials and facilities available. A wipe down with a water- or oil-soaked cloth is better than no cleaning at all. The importance of frequent cleaning cannot be overemphasized. However, any cleaning procedure used should always be the mildest method which will produce the desired results. For example, steam cleaning is a very effective method for removing soils and residual grease, but it also may erode paint and damage electrical insulation. The Aircraft Cleaning and Corrosion Control Manual for Organizational and Intermediate Maintenance Levels, NavAir 01-1A-509, covers procedures to be used in cleaning aircraft. This manual should be referred to for detailed information on materials, methods, and equipment.

In general, turbojet engines should be cleaned as often as necessary to keep surfaces free of salt, soil, and other corrosive deposits. More specifically, a thorough cleaning should always be accomplished as a part of each calendar inspection. Such routine or periodic cleaning should include the removal of all oil, water, and engine exhaust deposits; the replacement of contaminated supplementary preservative coatings; and a thorough cleaning of all external surfaces.

The amount of cleaning necessary between periodic inspections varies with operating conditions, but for ship-based aircraft any period of foul weather should be followed by fresh water to remove salt deposits. If fresh water is not available, waterless cleaner may be used for limited shipboard cleaning. In any type of cleaning, make sure that salt solutions and cleaning

compounds are not washed into internal areas and allowed to become trapped. Mask or seal vents and openings necessary to prevent this. Following cleaning, rinse out and drain exposed cavities to assure that residual cleaning materials have all been removed.

Engine frontal areas and cooling air vents are being constantly abraded with airborne dirt and dust, bits of gravel from runways, and rain erosion, which tend to remove the protective finish. In addition, air intake ducts, cooler radiator cores, etc., are not painted. Engine accessory mounting bases usually have small areas of unpainted magnesium or aluminum on the machined mounting surfaces. With moist, salt-laden air constantly flowing over these surfaces, they are prime sources of corrosive attack. Inspection of such areas should also include all sections in the cooling air path, with special attention to obstructions and crevices where salt deposits may build up during marine operations. It is imperative that incipient corrosion be inhibited and that paint touchup and hard film preservative coatings be maintained intact on seaplane and amphibian engine surfaces at all times.

Equipment

In emergencies where regular waterproof canvas covers are not available, suitable covering and shrouding may be accomplished by using polyethylene sheet, polyethylene-coated cloth or metal foil barrier material. These covers should be held in place with specification tapes designed specifically for severe outdoor applications. All covers and shrouds should be installed in such a manner that free drainage is assured. Do not create a bathtub which will trap and hold salt water. Shrouds or covers may also act as a greenhouse in warm weather and cause collection and condensation of moisture underneath. They should be loosened or removed and the aircraft ventilated on warm, sunny days. Where protection from salt spray is required aboard carriers, leave covers in place and ventilate only in good weather. Fresh water condensate will do far less damage than entrapped salt spray.

CHAPTER 7

TURBOJET POWERPLANT REMOVAL AND INSTALLATION

This chapter deals primarily with the general procedures involved in turbojet powerplant removal and installation. The step-by-step procedures for removal and installation of a specific turbojet powerplant can be found in the applicable technical instructions and should be used as a guide in the actual removal and installation procedure.

Turbojet powerplant removal and installation or "engine change" includes the following requirements: access door removal, powerplant removal, powerplant installation (including proper hookup and rigging), systems adjustment, and complete system checkout for flight.

The first part of this chapter deals with preparation and safety of equipment. The J52-P-6 turbojet engine installed in the A-6A aircraft is covered as a typical installation. Powerplant preservation and depreservation are covered in the latter part of the chapter.

ORDERING, INVENTORYING, AND ACCOUNTING FOR THE QEC

The ADJC must know the procedures for ordering, inventorying, and accounting for quick engine change kits (QECK) and spare engines.

Quick engine change kit (QECK) is a kit containing all items required for a quick engine change assembly, less government furnished accessories and the engine. Quick engine change assembly (QECA) is a quick engine change kit completely assembled on a quick engine change stand with the engine and all the accessories.

The initial requirement for the QECK is determined by the Naval Air Systems Command. When such a requirement is established, the QECK is procured from the airframes contractor and allocated in sufficient quantities to meet initial outfitting requirements. The Aviation Supply Office can fill supplement section BRAVO requirements for newly formed squadrons where complements of existing squadrons have been reduced.

Accounting for the QECK is the responsibility of the supply department, but in some cases the ADJ is responsible for the inventory of the kit. Reports of quick-change kits, of which the QECK is considered one, are required monthly from all reporting activities. If a supervisor has custody of a QECK he must make his reports to the local supply activity on time to insure timely preparation of the consolidated report to the Naval Air Systems Command.

A QECK should not be uncrated for replacement of overage components or incorporation of applicable changes. Outstanding changes beyond a using activity's capabilities are installed prior to issue.

NOTE: The powerplants supervisor must take necessary steps to insure that the QECA in his custody is not used for a ready source of spare parts. He can accomplish this by proper indoctrination of his workers and proper security measures.

ENGINE DISPOSAL PROCEDURES

It is the responsibility of the ADJ to know the procedures for the disposition of aircraft engines removed from service. To know this he must be familiar with the system used by the Naval Air Systems Command. Each model of aircraft engine is assigned to one of the following classifications, and by this classification the disposition of the engine is determined.

CLASS I AND II

These engines are installed in currently operating naval aircraft or scheduled for installation in new aircraft.

CLASSES IIIA AND IIIB

These engines are installed in current operating naval aircraft, aircraft held in reserve stock or contingency reserve, and aircraft on bailment, loan, or lease.

CLASS IV

Class IV engines are obsolete. These engines are no longer required to support aircraft in the current naval operating program, but are being retained for training purposes, special projects, cannibalization, or conversion to an acceptable configuration.

CLASS V

These engines are obsolete and excess to the requirements of naval aviation.

DISPOSITION

Serviceable class I, II, IIIA, and IIIB engines are Navy required and should be reported on the aircraft engine accountability report form.

Unserviceable class I and II engines located within the continental limits of the United States are disposed of as follows:

1. Engines removed from aircraft due to engine failure or high time, and damaged spare engines should be shipped to the designated overhaul activity.
2. Engines installed in aircraft stricken in categories 1, 2, and 4 are to be recovered and shipped to the designated overhaul activity unless the Naval Air Systems Command specifically authorizes disposal simultaneously with the aircraft.
3. All engines referred to must be reported on form NavAir 13700/2 under the applicable codes.
4. The Naval Air Rework Facilities must determine the feasibility of overhauling damaged engines or recommend disposal by strike in accordance with current instructions.

Unserviceable class IIIA engines located within the continental limits of the United States are retained at the present location or point of generation pending disposal instructions. Engines in this classification located at a designated overhaul activity can be utilized for support of limited overhaul requirements as necessary.

Unserviceable class IIIB engines and all class V engines, both serviceable and unserviceable, located within the continental limits of the United States are disposed of as follows:

1. If in reportable condition, engines in these categories must be retained at the present location or point of generation, and reported to the supply department. The supply department furnishes the holding activity an automatic release date after which the engine may be disposed of without further authorization.
2. Engines installed in aircraft stricken may be retained with the aircraft and reported in the applicable status code. Upon final disposition of the aircraft, the engines may be disposed of simultaneously without further authorization.

Unserviceable class II, IIIA, and IIIB engines and all class V engines, both serviceable and unserviceable, located outside the continental limits of the United States must be disposed of as excess in accordance with instructions set forth by Navy Property Redistribution and Disposal Regulation No. 1, as amended.

Serviceable and unserviceable class IV engines, both installed and spares, should be retained at the present location pending disposal instructions from the Naval Air Systems Command.

When an aircraft is stricken because it is lost or missing, or suffers complete destruction, the engines which were installed are expended with the striking of the aircraft.

Spare engines damaged to the extent of complete destruction are the subject of local survey action and subsequently are stricken.

Engines determined as excess in accordance with NavAir Instructions and reported to the proper authority are retained, pending disposal by transfer or donations. No accessory or part shortage is filled or rework accomplished on such engines. Engines classified as excess by the Naval Air Systems Command and awaiting disposition by scrap or salvage do not require further preservation or protection.

GENERAL PROCEDURES

In the past, removal and installation of an aircraft powerplant was a time-consuming job. The ADJ in charge of the crew assigned to remove and install a powerplant would have a long list of parts and equipment to assemble before the actual work began. The crew leader would have to gather workstands, engine stands, mobile cranes, drip pans, bales of rags, and other miscellaneous equipment.

As naval aviation progressed, new equipment was developed; and at the present time, most turbojet powerplants may be removed and installed with one universal installation/removal trailer, with adapters for different powerplants. On some installations aero bomb hoists are used in conjunction with the installation/removal trailer.

EQUIPMENT

The installation/removal trailer (air logistics model 4000A) is used to remove and install the powerplant. Actual work is normally performed after the powerplant has been transferred to the model 3110 workstand. The model 3110 workstand is usually in a fixed location in the hangar or powerplants work center.

Removing and installing a turbojet powerplant involves more than the actual removal and installation procedures. Parts must be removed from the path of the removal and installation. These parts must be cleaned, inspected, and stored. Safety precautions must be followed. Quality Assurance inspections are required throughout the engine compartment and of the work being performed. Removal and installation procedures will vary on the same type aircraft due to the location of the aircraft. Ashore, the aircraft could be spotted on the line or in the hangar. Aboard a carrier, it might be spotted in the hangar bay or on the flight deck.

NOTE: The air logistics trailer, the model 3110 workstand, and aero bomb hoists are covered extensively in ADJ 3 & 2. Therefore, only limited coverage of these items is provided in the following paragraphs.

Air Logistics Trailer (Model 4000A)

The air logistics trailer (model 4000A) is used to facilitate the removal, transfer, and installation of turbojet powerplants. Installation, transportation, and disassembly adapters are provided for the powerplant. These adapters mate with the trailer's parallel rails and other elements of the ground handling equipment. Precision positioning of the powerplant is achieved through a combination of hydraulic and irreversible-screw-type actuators on the air logistics trailer. These controls provide fore and aft, tilt, roll, and yaw movement of the paralleled rails.

The parallel rail ground handling system permits the transference of the powerplant from one set of rails to another. After the rails are alined, leveled, and locked together, the powerplant is rolled onto the stationary stand for the work to be performed.

Workstand Assembly Model 3110

The model 3110 workstand is a 48-inch gage matching rail type unit designed to mate with rail type trailers for the roll transfer of the load along the rails. The model 3110 workstand is usually mounted in the hangar or powerplants shop and is used for horizontal maintenance and storage of aircraft powerplants.

Aero Bomb Hoists

Aero bomb hoists are used in conjunction with the air logistics trailer for powerplant removal and installation in some aircraft. Prior to using an aero bomb hoist to raise or lower a powerplant, the cable should be checked for frayed, worn, or broken strands. Check for proper routing of the cable on the drum to prevent cable slippage or jamming during powerplant removal and installation.

Never leave a powerplant unattended while it is being supported by the hoists. When lowering a powerplant, constantly observe the powerplant clearance with the aircraft nacelle to prevent damage to the powerplant or nacelle.

REMOVED PARTS

Access to components and various systems during turbojet powerplant removal and installation involves removal and installation of many access doors, panels, tubing, lines, and clamps. With the vast number of doors and door fasteners, trial and error door removal during maintenance is time consuming. To minimize door manipulation, the applicable technical instructions should be consulted to enable maintenance personnel to determine the specific doors involved when performing maintenance tasks.

Care must be taken to preserve the painted surfaces of any doors removed as well as the aircraft. The doors or parts removed must be thoroughly cleaned, inspected, and properly stored for protection against corrosion and physical damage.

When handling high-stress access doors, observe care to prevent damage. Scratches,

nicks, and bends must be prevented as they tend to cause fatigue failure.

When performing various maintenance procedures, certain access doors are required to be in place on the aircraft to provide structural rigidity. These access doors should be reinstalled as soon as possible after removal to prevent damage to the aircraft.

SAFETY PRECAUTIONS

Prior to removal and installation of a turbojet powerplant the aircraft should be in a clean workspace, free from foul weather disturbances. Adequately secure the aircraft with wheel chocks or with tiedown provisions. Turn off all electrical power to the aircraft. Install protective plugs and caps on all openings, lines, and electrical connectors when disconnected or removed.

Care must be taken when maneuvering the installation/removal trailer around the aircraft to prevent damage to the powerplant and the aircraft nacelle. Be careful when guiding the trailer past the landing gear to prevent damage to hydraulic brake lines.

Cleaning of the engine inlet and nacelle area cannot be overemphasized in order to protect the engine from entry of foreign materials which will cause serious damage to the engine. Vacuum clean all areas in and around the engine inlet ducts and the engine nacelle after any maintenance or before and after installing an engine.

Account for each nut, bolt, washer, safetywire, etc., used or replaced during any powerplant maintenance. When transporting powerplants or trailers on trucks, make certain that the inlet sections of the powerplant are adequately covered. If the powerplant is not to be installed in the aircraft in the immediate future, reinstall the engine closures and cover the engine with a clean, light canvas or wrapping paper.

Do not start an engine before accounting for every tool and all equipment used in the vicinity, and thoroughly inspect the inlet duct area for loose objects. Install intake screens prior to ground runup of the powerplant. Never wear loose clothing or carry rags or gloves in pockets when walking around engines in operation.

Use care when operating an engine on the ground or deck. Use no more power than necessary. This will reduce the suction power of the engine.

FOREIGN OBJECT DAMAGE (FOD) AND QUALITY ASSURANCE

The objective of aircraft maintenance is to insure the highest state of readiness and reliability at the lowest cost in men, money, and material. Two of the controlling factors in achieving this goal are FOD prevention and quality assurance.

Due to the large area and different work centers involved in a turbojet powerplant removal and installation, FOD potential is great. Therefore, the need for good quality assurance is greater.

There should be little doubt as to what constitutes foreign objects. Actually a foreign object may be anything that can pass through a compressor or turbine rotor or find its way into a sump, a fuel tank, or a lube tank with the potentiality of causing damage to the powerplant and its components.

Toolboxes are a great source of foreign objects. Every time something is taken from a toolbox, and not returned immediately after use FOD potentialities climb sky high. Engine after engine has been damaged with stray wrenches, screwdrivers, and flashlights.

Toolboxes must be checked and rechecked. All parts, nuts, bolts, washers, and safetywire must be kept off the floor, the deck, the turnup areas, and any other place where there is the slightest possibility that they might get into an engine.

Personal belongings must be carefully guarded, even to the extent of emptying pockets before approaching an engine. Nothing must be placed near inlets of engines which could be forgotten.

The quality assurance concept is fundamentally the prevention of the occurrence of defects. This concept embraces all events from the start of the maintenance operation to its completion.

Prior to the powerplant installation, a thorough inspection of the aircraft and powerplant should be conducted. If any maintenance has been done in the nacelles or inlet ducts which required removal of sealants, insure that all affected areas are resealed prior to the powerplant installation.

Inspect the nacelle area, including small openings, niches and indentations, for foreign materials. Inspect the engine mount wells and mounting brackets. Check all electrical boxes and conduits, fire detector elements, and clips.

Check all lines, hoses, cables, and electrical wiring for correct installation and security. They should be secured with clamps at proper intervals to prevent vibration and chafing. With the use of a bright light, inspect the front stages of the compressor section and the aft turbine stages for foreign material.

If any further cleaning is required, it should be accomplished with a vacuum cleaner. Air pressure should not be used for cleaning. If any work other than a powerplant installation is accomplished in an area after inspection, the area and adjacent areas must be reinspected.

ENGINE REMOVAL AND INSTALLATION

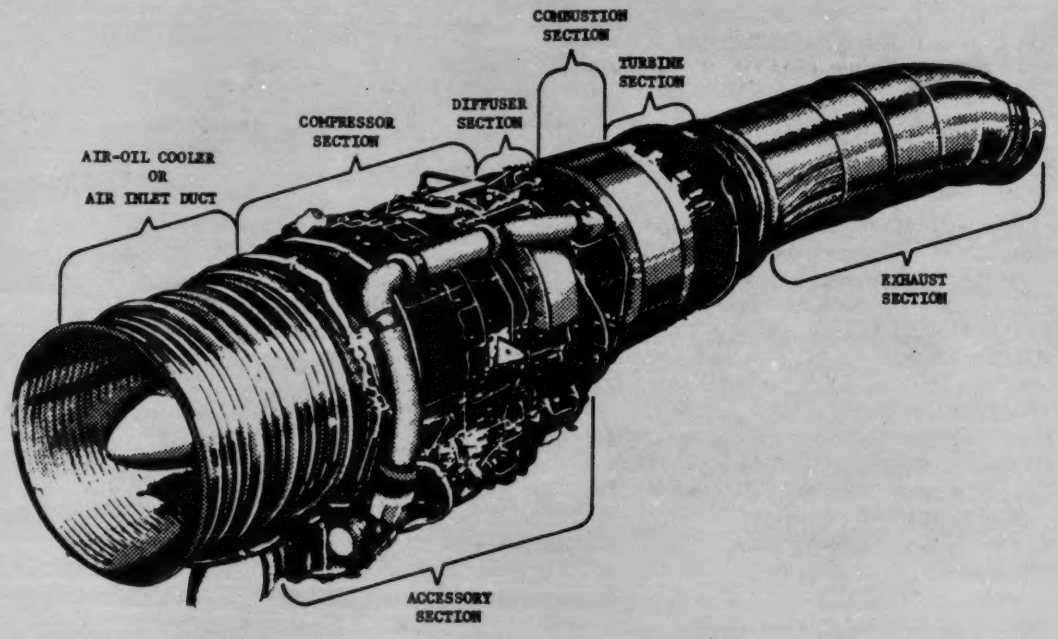
The aircraft used in this presentation of axial-flow engine removal and installation is the A-6A aircraft. The A-6A aircraft is equipped with two J52-P-6 or J52-P-6A engines. The engine and all engine-mounted accessories form a QEC (quick engine change) which may be replaced by a similar unit. A three-point, two-plane mounting retains the engine in the engine compartment and simplifies engine removal and installation.

The engines are installed on either side of the aircraft keel in the engine compartments, which are positioned low and forward on the fuselage. The engines are accessible through the forward and aft engine access doors, which are removed to expose the lower halves of the engines for maintenance and inspection.

The right and left powerplants (engine and related system accessories) are completely interchangeable, except for the tailpipes, which are contoured to fit each side of the aircraft. (See fig. 7-1.)

REMOVAL

To remove the powerplants from the A-6A aircraft, two aero bomb hoists are required to lower the powerplant to the installation/removal trailer. The aircraft should be as level as possible and secured either with wheel chocks or tie-down provisions. If the powerplant is to be removed on an aircraft carrier while operating at high seas, install the engine guide rail kit to



AD.236

Figure 7-1.—J52-P-6 turbojet powerplant.

prevent the powerplant from hitting the aircraft structure. Figure 7-2 shows the aft engine guide rail installed, and figure 7-3 shows the forward engine guide rail installed.

Preliminary Procedures

Verify that all electrical power is off. Remove the necessary fairing and access doors. Install the forward and aft bomb hoists in the fittings provided on the aircraft structure and attach the cables to the forward and aft engine mounts.

With the aero bomb hoists installed and attached to the engine, follow the recommended procedures and disconnect all lines, fittings, and electrical connections. Before continuing with the removal procedure, verify that all connections between the engine and the airframe have been disconnected.

Lowering Engine

Operate both hoists until a slight strain is on the cables, remove the pip pin from the forward engine mount, and remove the bolt that secures the aft engine mount to the aircraft mount. With the forward and aft engine adapters in place, position the engine installation/removal trailer under the engine. (See fig. 7-4.) Operate the forward and aft hoists together to lower the engine. When the engine is in position, attach it to the trailer adapters with the pip pins. Remove the trailer from the area under the engine compartment and remove the aero bomb hoists from the aircraft. Install protective plugs and caps on all openings, lines, and electrical connectors when disconnected or removed.

Removal and Assembly of QEC

When the engines are to be replaced on the aircraft, remove the aircraft-furnished accessories and equipment, either for installation on the replacement engine or for overhaul, as required. Note carefully the location and attachment of all units before removal as an aid to assembly of the replacement engine. When accessories are to be sent to overhaul or storage, preserve them in accordance with the applicable technical instructions, and attach all pertinent data and the proper accessory record cards.

After removal of the aircraft-furnished accessories and equipment, cover all exposed drives and ports. Prepare the engine for shipment, storage, or disassembly, as directed in applicable instructions.

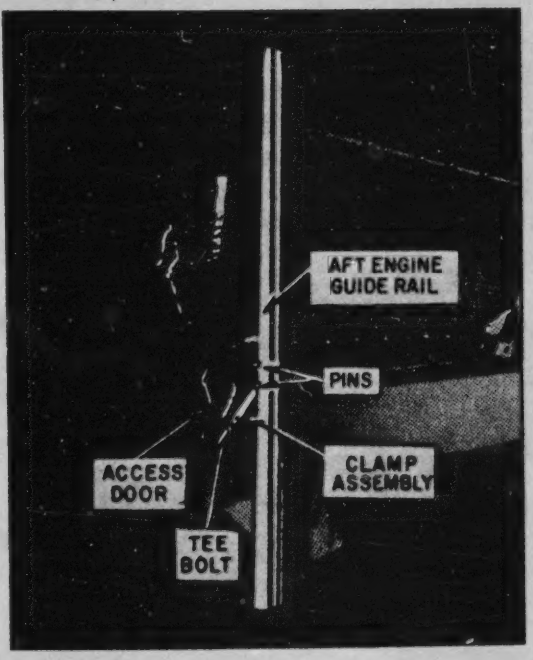


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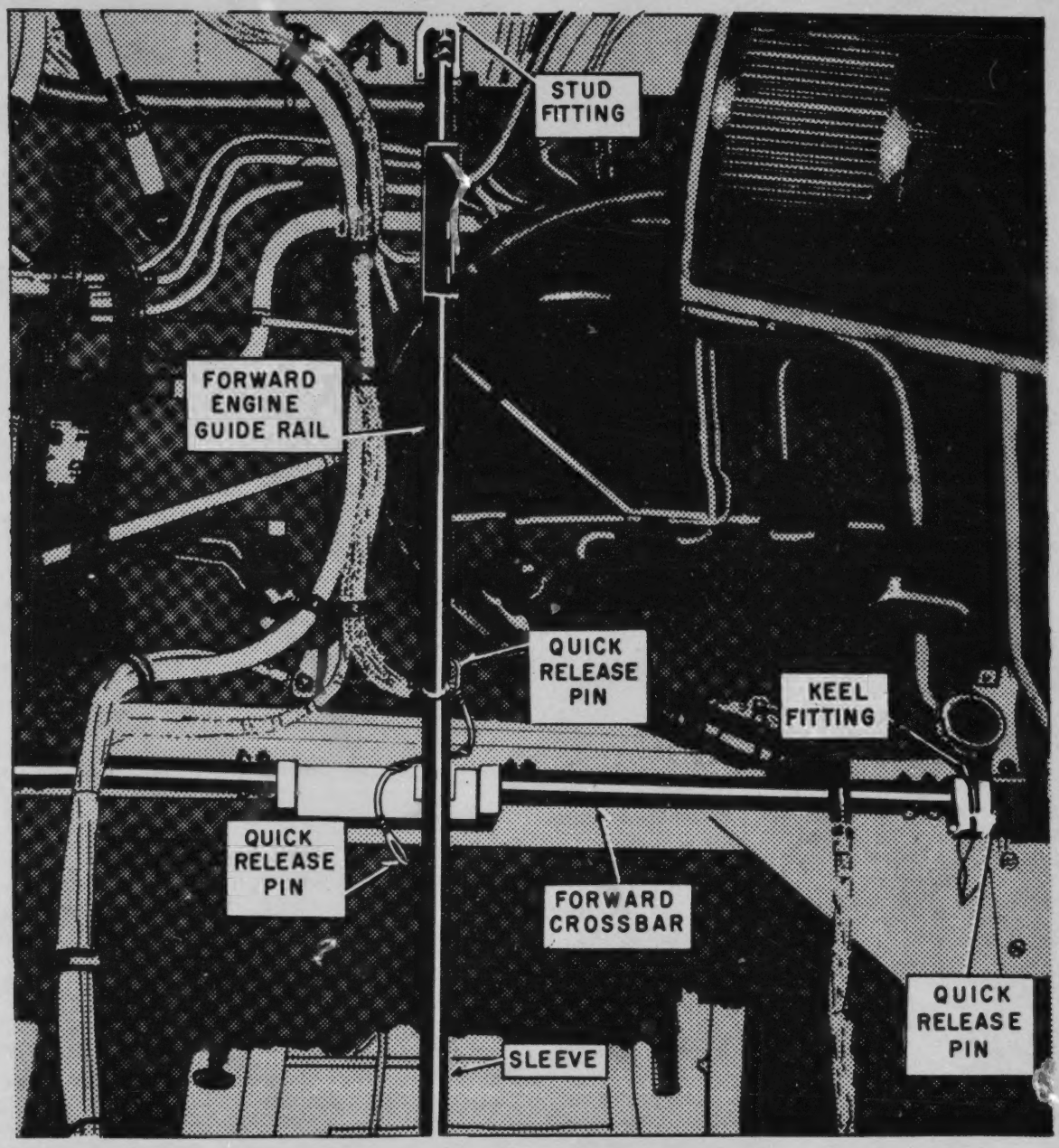
Figure 7-2.—Aft engine guide rail installed.

Reinstall the accessories and equipment removed from the replaced engine or install similar new or overhauled units. Inspect all accessories for condition and correct adjustment before installation. Use all new O-rings, gaskets, and cotter pins on all installations. Use the torque values specified in the table of limits for each accessory or assembly. The table of limits can be found in the applicable technical publication.

Prior to installing the powerplant in the aircraft, inspect the engine compartments in the aircraft thoroughly for foreign objects or loose articles. Inspect the engine for security of all accessories, lines, and clamps.

INSTALLATION

Prior to installing the powerplant in the aircraft, a functional test of the fire detecting



AD,238

Figure 7-3.—Forward engine guide rail installed.

system should be accomplished. Disconnect the electrical power from the aircraft after the test is complete. Install the two bomb hoists in the engine nacelles. Remove all caps, covers, and plugs from the lines and receptacles in the nacelle and on the engine to be installed.

Position the engine and trailer under the engine compartment, taking care not to bump the hydraulic brake lines or aircraft fuselage. (See fig. 7-4.) Attach the bomb hoist cables to the forward and aft engine mounts. Operate both hoists until a slight strain is on the engine, remove the pins securing the engine to the trailer, raise the engine enough to clear the trailer, and remove the trailer clear of the aircraft. Operate the hoists together to keep the engine horizontal. Carefully guide the engine mounts into the aircraft mounts to prevent damage to the engine or aircraft.

Adjust the bolt on the rear mount for lateral adjustment of the engine, and adjust the tailpipe support rod for vertical adjustments. Refer to the current technical publications for the proper clearance prior to making adjustments.

Connect all lines, fittings and electrical connections. Remove the bomb hoists and inspect

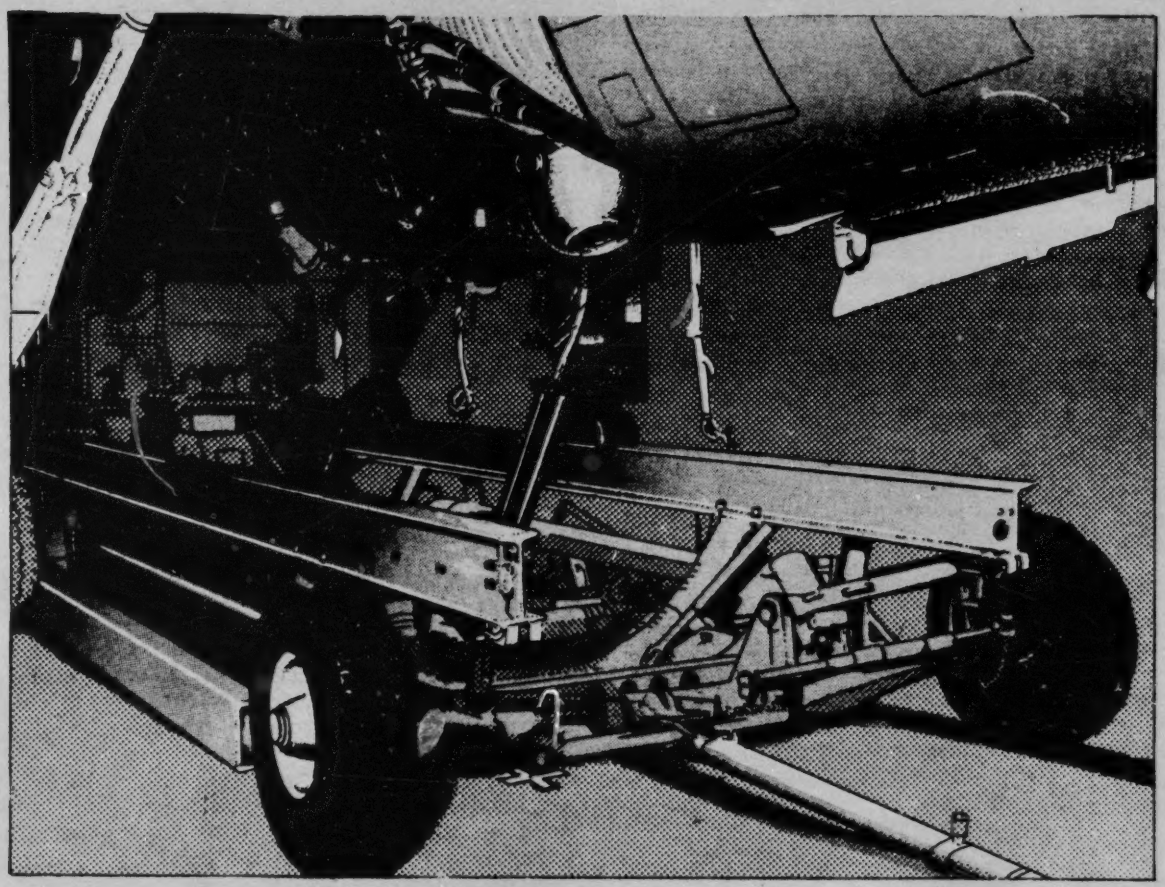


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Figure 7-4.—Engine installation/removal trailer in position.

the entire installation for completeness and security. Check thoroughly for foreign objects and loose articles. Check the power control rigging and trim the engine if required. Reinstall all fairing and access doors.

ENGINE TESTING AND EVALUATION

Run-in of an engine after engine change is essential as a means of checking the performance of the engine and recording the performance data on log sheets. For each condition from idle speed through takeoff, all these indications (the thrust, fuel and oil pressures, fuel consumption, oil temperatures, compressor inlet air temperature and pressure, compressor discharge temperature and pressure, and the exhaust gas temperature) are read and recorded. The engine check charts provide the general operating conditions, limits, and test curves for each engine model. All the preceding indications of thrust, fuel consumption, temperatures, and pressures are then compared with the engine model check charts to evaluate the performance and condition of the engine. Personnel must follow the procedures outlined in the applicable technical instructions which concern the engine model being tested.

PRESERVATION AND DEPRESERVATION

Aircraft engines are the most expensive single item of support in the Naval Logistics System, both in terms of unit cost and total dollar expenditures. The sizable investment in aircraft engines and the continually rising cost of new models of engines require close management control to shorten out-of-service time and reduce quantities of spare engines being procured. One of the major contributions to achieving this goal is proper preservation and depreservation. General procedures used in the preservation and depreservation of turbojet engines are discussed in the following paragraphs.

GENERAL PROVISIONS

The following paragraphs cover preservation materials, equipment, and procedures in general. When preservation of a specific turbojet engine is required, the applicable technical instructions must be consulted.

Lubricating Oil System Preservatives

Experience has shown that under ordinary conditions preservative type oils are not required for the oil bathed portions of turbojet engines. Unless otherwise directed for a particular situation or engine type, the specified normal lubricating oil must be used as a preservative medium for the lubricating system of turbojet engines for all types of storage.

Hydraulic Oil System Preservatives

Separate hydraulic oil systems, such as the J79 afterburner control, are preserved by maintaining the fluid system full of the specified operating fluid. If the hydraulic system is to be totally or partially drained during the storage period, it must be flushed with the preservative fluid specified for the type of system involved.

Fuel System Preservatives

The preservative used for all types of turbojet fuel systems is an approved jet engine oil. This is a petroleum-base oil, free of all additives except oxidation inhibitors and pour-point depressants, used to minimize the danger of gum formation in critical passages.

Preparation of Corrosion-Preventive Compounds

To prevent contamination of lubricating oil systems with can sealants, rust particles, and metal slivers resulting from opening of metal containers, lubricating oil should be filtered through 10-micron filters before being added to gas turbine engine oil reservoirs. The lubricating oil should be pumped directly from the filtering unit into the reservoir, as contamination may be reintroduced in transferring the oil to a separate container before use.

Except for a general requirement that all oils must be water free, preheating is not required for gas turbine engine lubricating oil used for preservation runs. Oils are considered water free if containers are kept closed until just before use. If contamination with water is suspected, heat the oil or preservative mixture to 102° C to 107° C (215° to 225° F) for at least 15 minutes, to drive off any suspected water.

Jet engine lubricating oils used for preservation of fuel systems are filtered through compound type filters not larger than the

smallest filter in the engine fuel system. At the present time 5-micron filters are required in most turbine engine fuel systems.

Reuse of Corrosion-Preventive Compounds

For preservation purposes fuel system preserving oil may be reused until it has become diluted with service fuel. Dilution of fuel system preservative may be determined by comparison with known mixture of the proper oil and the various service fuels, using an API gravity hydrometer.

Engine oil reservoirs should be serviced with new lubricant when conducting preservation runs. Lubricating oil should not be transferred from one engine to another where the oil reservoir is part of the engine. Where the lubricating oil reservoir is part of the test cell installation, a batch of lubricating oil may be used for up to 50 hours of accumulated operating time if the oil is filtered through at least a 10-micron filter before entering the engine oil system, and if laboratory controls are used to maintain the quality of the lubricant. When lubricating oil is present in individual engine oil reservoirs, periodic oil change requirements should be observed as a part of the preservation procedure. For this purpose, lubricating oil should be changed if it has accumulated 75 percent or more of its recommended maximum operating time.

NOTE: Following internal preservation, the following warning and preservation tags must be installed:

1. One warning tag which reads "THIS CONNECTION WAS DISTURBED DURING PRESERVATION—CHECK FOR LEAKS AT ENGINE RUNUP" must be placed on each fuel and oil fitting disturbed during preservation.
2. One warning tag which reads "OIL RESERVOIR DRAINED" must be placed on the engine start switch or button, if the oil reservoir is drained.
3. A properly filled out preservation tag, which gives the type of preservation, preservatives used, activity, date, etc., must be placed on the control panel or in a similar conspicuous place.

PREPARATION OF ENGINES

To accomplish satisfactory preservation, the surfaces must be thoroughly cleaned wherever practicable before application of the preservation compound. Not only is any surface contamination capable of picking up moisture from the surrounding air, but also it may be of such a composition as to result in direct chemical attack. New or newly overhauled engines may usually be externally cleaned by removing grease and oil from the surfaces. Particular care must be taken to clean the protruding portion of a propeller shaft. For cleaning of this nature, usually accomplished between the preservation run and final preservation, an approved dry-cleaning solvent is recommended. If it is not available, kerosene may be used. However, kerosene is not considered as useful as dry-cleaning solvent because of the evaporation time. Surfaces must be both clean and dry prior to application of the preservative compounds.

For engines being returned for overhaul or minor repair, a proper balance should be maintained between cleaning and leaving satisfactory preservative compounds in place. No general rule can be made except that corrosion-preventive compounds allowed to remain should be free of dirt. Steam cleaning with the proper steam cleaning compound usually removes most soils. If the engine is excessively oily, greasy, or coated with old preservative compounds, a presoak for approximately 15 munites with a spray-applied mixture of six parts of kerosene and one part of grease cleaning compound, should provide sufficient softening to permit steam cleaning to function. If the engine is not excessively coated with foreign matter, the use of kerosene alone may give satisfactory results. Again, great care must be used to insure proper cleaning.

PRESERVING THE TURBOJET AND TURBOFAN ENGINES

The procedures to be followed in the preservation and depreservation of turbojet and turbofan engines in service vary, depending upon the length of inactivity, the type of preservation used, and whether or not the engine may be rotated during the inactive period. In many cases there are no departmental directives covering the preservation and depreservation of new engines. In these cases the manufacturer's instructions must be complied with. Preservation of oil and fuel systems is discussed in the following paragraphs.

Oil System (TF30)

The following procedures apply to TF30 engines that are to be inactive for a period in excess of 90 days.

Open oil drains at the bottom of the oil tank (gearbox) and remove. Drain the oil into a suitable container. Remove the main oil strainer and rinse the assembly in petroleum solvent; then coat with oil, Military Specification, MIL-L-23699. Install the oil strainer and close the previously opened drain.

Remove the cover plates from pads of accessory drives and coat the exposed surfaces with Grade 1010 oil. Reinstall the cover plates.

Install plugs, caps, covers, or screens over all openings to keep out foreign material and moisture. If the engine is to remain in the aircraft, install 52 pounds of dehydrating agent. (26 pounds in the engine compartment and 13 pounds in the intake and exhaust.)

Oil filler caps must be tagged as to preservative used and date of preservation. Using an airtight moisture barrier or other suitable covers, cover the air inlet and exhaust end of the engine compartment. Install a humidity indicator at each end. (Inspection windows at each end should be provided through which the indicators will be visible.)

Inspection of the preserved unit should be made every 2 weeks if the aircraft is stored inside. If relative humidity as indicated on the humidity cards is 40 percent or less, no further action is required. If humidity indications are higher than 40 percent, the entire engine system, including the fuel and oil systems, should be depreserved, inspected for corrision, and represerved.

Fuel System (TF30)

With the fuel OFF and the engine fuel system pressure bleed OFF, prepare the engine fuel and control systems in the following manner.

NOTE: To prevent inadvertent engine lightup during preservation, disconnect both ignition generator output leads.

Check when the fuel and control system fluid temperature is in a cool-to-warm condition (hand may be held on lines). Extreme care must be taken to prevent foreign matter from entering the fuel system. Therefore, the flushing oil supply to pump inlets must contain 25-micron filters and the flushing oil supply to servo systems must contain 2- to 10-micron filters.

Remove the filter cover assembly from the fuel pressurizing and dump valve and provide an overboard drain container. Disconnect the fuel inlet tube to the engine fuel pump and connect a supply of Grade 1010 oil at a pressure of 25 to 35 psig at a minimum temperature of 15.6 ° C (60 ° F). Disconnect the pressure ratio bleed control at the control body pressure fitting on the fuel control and connect the tube to an overboard drain container. Cap the control body pressure fitting on the fuel control.

With the stand fuel shutoff valve closed and ignition OFF, select the NORMAL system of the fuel control. Move the power lever to the maximum position. Motor the engine with the starter to a minimum high compressor speed (N_2) of 2,500 rpm. While the engine is motoring, move the control power lever from maximum to shutoff to maximum. Activate the derichment valve on and off three times.

Continue or repeat the engine motoring until at least 4 gallons of fluid have been obtained in the overboard container connected to the fuel pressurizing and dump valve.

Select MANUAL system of the fuel control. Move the power lever to the maximum position. Motor the engine with the starter to a minimum N_2 speed of 2,500 rpm. During motoring, move the control power lever from maximum to shutoff to maximum. Continue or repeat the motoring until at least 2 gallons of fluid have been obtained in the overboard container connected to the fuel pressurizing and dump valve.

NOTE: During the above procedures a minimum of 0.25 gallon of fluid must have been obtained from the pressure ratio bleed control return tube.

Return the fuel control to the NORMAL position. Connect the pressure ratio bleed control return tube and secure. Disconnect the flushing oil supply to the engine fuel inlet. Using new seals, install the fuel pressurizing and dump valve cover and secure. Install plugs, caps, covers, or screens on all openings.

Fuel and Oil System (J79)

Service the engine oil tank with enough oil to provide lubrication during starter rotation. Attach a supply of the approved filtered oil at 15 to 25 psig at the main and afterburner fuel inlets. Disconnect the compressor discharge pressure line from the compressor rear frame and attach a regulated supply of shop air to the removed line. Provide a valve to cycle the shop air from

0 to 90 psig. Then remove the pressurizing and drain line to catch the fuel and oil. Remove the pressure hose from the main oil cooler. Provide a drain line to catch the fuel and oil. Remove the reference pressure hose from its elbow at the rear of the pressurizing and drain valve. Cap the removed line. Disconnect the afterburner metered fuel line at the flow divider. Then disconnect the afterburner ON-OFF signal line at the main fuel control or at the afterburner ON-OFF valve, whichever is more accessible. Attach a supply of oil at 100 to 150 psig to the afterburner ON-OFF valve.

Cap the opening leading into the fuel control. Provide containers under all openings and drain lines to catch the fuel and oil. With the power lever open, rotate the engine at 4 to 7 percent rated rpm, using air at 25 psig. The starter may be used for this operation if the air temperature is within limits. When fuel-free oil is discharged from the main oil cooler drain line, cycle the shop air and throttle twice, leaving the power lever in the CLOSED position. Allow the engine to coast down and cut off the oil supply. Fill the pressurizing and drain valve with the proper oil and cap all openings with fluidtight closures. Remove the preservation rig. Reconnect all fluid system openings with fluidtight closures. Using lockwire, secure the power lever in the CLOSED position. Make every attempt to leave the engine fuel system full of the preserving oil. Do not drain.

DEPRESERVING THE TURBOJET AND TURBOFAN ENGINES

As previously stated depreservation as well as preservation of turbojet and turbofan engines in service varies, depending upon the length of inactivity, the type of preservation used, and whether or not the engine was rotated during the inactive period. Depreservation procedures are discussed in the following paragraphs.

Oil System (J79)

The oil system does not require any depreservation. All that is required is to fill the oil tank with lubricating oil.

Fuel System

The fuel system can be depreserved by performing a wet prestart, without ignition. Open the throttle 78° to 80° for 30 seconds, or until fuel pressure is observed. If depreserved engines appear sluggish in operation, it is recommended that the engine be run for a short period of time at various low speeds rather than immediately rejecting a component. This operation may remove air locks in the controls. Engine operation should be satisfactory after an hour of operation is accumulated.

Oil System (TF30)

Remove all preservation and service the oil system with fresh oil, Military Specification, MIL-L-23699.

Fuel System (TF30)

Remove all moisture barriers, humidity indicators, and dehydrating agent. After filling the engine oil tank with the proper lubricating oil, connect a fuel inlet line to a fuel supply that contains 25-micron filters. Open the main pump interstage filter drain and control body pressure drain, and remove the filter cover assembly from the fuel pressurizing and dump valve. Allow all residual oil to drain. Connect a supply of clean engine fuel (Grade JP5) to the inlet of the fuel pump.

Motor the engine with the starter at a minimum N_2 speed of 2,500 rpm. During the motoring, move the control power lever continually from shutoff to maximum to shutoff. Hold the power lever for 10 seconds at each position. Electrically energize the manual fuel system during alternate motoring cycles. Continue or repeat the engine motoring until at least 2 gallons of fuel have been obtained from the fuel pressurizing and dump valve.

Discontinue the engine motoring and close the engine fuel pump interstage filter drain. Close the engine fuel control body pressure plug on the bottom of the control.

Motor the engine with the starter at a minimum N_2 speed of 2,500 rpm. During the motoring, move the control power lever continually from shutoff to maximum to shutoff. Hold the power lever for 10 seconds at each position. Electrically energize the manual fuel system during alternate motoring cycles. Continue or repeat the engine motoring until at least 1 gallon of fuel has been obtained from the fuel pressurizing and dump valve. Reinstall the filter cover assembly on the pressurizing and dump valve to secure the engine fuel system.

NOTE: As previously stated, correct preservation/depreservation of aircraft engines is one of the controlling factors in the service life of the engine. Therefore, the supervisor must insure that all preservation/depreservation information is relayed to Maintenance Control expeditiously in order that it can be recorded in the appropriate logbook.

CHAPTER 8

TURBOJET POWERPLANT HOT SECTION REPAIR

This chapter is intended to familiarize the ADJ with different types of turbojet engine hot sections (J57, and J79) and some of the repair limits for these hot sections. Disassembly of an engine should never be attempted until complete familiarization is attained with the step-by-step procedures contained in the current technical publication for the particular engine.

The information contained in the first section of this chapter is general and applies to most turbojet engines. Repair limits for the same part will differ from engine to engine due to the requirements of the manufacturer. Therefore, minor repair limits are listed by engines.

A Chief or First Class Aviation Machinist's Mate J may be assigned duties with an Intermediate maintenance activity. Therefore, he should be familiar with the equipment and procedures used to test turbojet engines after the engine is repaired. The last section of this chapter covers some of the procedures and equipment used by an Intermediate maintenance activity.

LOCAL REPAIRS TO ENGINE COMPONENTS

The Chief or First Class Aviation Machinist's Mate J must have the ability to determine the feasibility of local repairs to turbojet engines and components. He must insure that the proper manpower, equipment, and tools are on hand for accomplishing the job.

When an engine or component is reported to be malfunctioning the trouble can usually be located by efficient and systematic troubleshooting.

Once the trouble has been located, other questions arise. Are the resources available to do the job? What are the operating commitments of the squadron? Is the manpower available to accomplish the repairs as well as the routine commitments? Is the proper test equipment available locally that will be required after the necessary repairs are completed? Also, the time element must be considered. Can the engine or component be repaired in a minimum amount of time, or will it be a time-consuming repair that will hold the aircraft out of a flight status for an unusually long period?

Aircraft maintenance must be accomplished at the lowest level maintenance, as established by OpNav Instruction 4790.2 (Series), but maximum readiness must be maintained. If a repair will be time consuming and the aircraft will remain out of a flight status for a long period of time, the engine or component must be replaced and the replaced engine or component returned to supply to be repaired at a higher maintenance level or scrapped.

All of these factors must be considered in determining the feasibility of repairing a turbojet engine or component locally. Technical publications must be consulted for the repair limits and procedures to be used, but the feasibility of repairs rests with the powerplants supervisor who must operate within the guidelines, directives, etc., established by higher authority.

CLEANING

As soon as an engine has been disassembled, all engine parts should be cleaned thoroughly. Correct and thorough cleaning is of the greatest importance to successful inspection, field repair, and satisfactory operation after field repair. Normally an emulsion type cleaner should be used because they are neutral and noncorrosive. When using any type cleaner, follow the applicable technical instructions carefully to prevent damage to the parts being cleaned or injury to the person doing the cleaning.

GAGES

When an inspection procedure requires a very accurate measurement, a micrometer, vernier, or dial indicator must be used. If a micrometer is to be used, check it for accuracy before taking a measurement. Make sure that the contacting surfaces of the micrometer are clean and that the contacting surfaces of the part to be measured are clean and free from burrs. When using a depth micrometer, be sure to hold the anvil tightly and squarely against the contacting surface. If a dial indicator is used, make sure that the indicator support is firmly anchored and that any swivel connections are tightened securely. When taking a measurement with a feeler gage, the final size of the feeler must be a reasonably snug fit. Both the plug type and the flat type gages are used for measuring the amount of wear of bushings and similar parts.

GRINDING AND BLENDING OF PARTS

Grinding and blending of nicks and scratches must be accomplished in strict accordance with the applicable technical instructions. Some minor nicks and scratches may be removed by hand filing and blending. Deep nicks may be removed by grinding on a carborundum wheel and blended out with a cloth wheel coated with a buffing compound.

HOT SECTION HARDWARE

Correct engine reassembly procedures require that particular attention be paid to the material requirements for the nuts and bolts used in the hot section of the turbojet engine.

In these areas, where parts must be of material which is resistant to high operating temperatures, special heat resistance alloys are employed. It is imperative that a reassembly of the engine or its components the properly coded part be reassembled in its original location, if serviceable.

WELDING

Welding is permissible on some parts of the turbojet engine. Refer to the applicable technical instructions before attempting to repair an engine or component by welding.

TEMPORARY MARKING OF HOT SECTION PARTS

Certain materials may be used for temporary marking during assembly and disassembly. Layout dye (lightly applied) may be used to mark parts which are directly exposed to the engine gas path, such as turbine blades and disks, turbine vanes, and combustion chamber liners. A marking pencil may be used for parts which are not directly exposed to the gas path. This type of mark is easily obliterated and therefore less durable.

Any temporary marking method which leaves a heavy carbon deposit or a detrimental deposit of copper, zinc, lead, or similar residue may cause subsequent carburization or intergranular attack when the part is subjected to intense heat. Avoid the use of such method unless the marking is completely removed before the part is subjected to intense heat.

HOT SECTION REPAIRS

This section covers minor repairs and replacement of hot section components. The engine is considered completely stripped although in doing actual maintenance it may not be necessary to remove all of the tubing or components. Experience will dictate which tubing or component must be removed to effect the necessary repairs.

In the process of engine disassembly, numerous associated parts not directly in the removal path will be readily accessible for inspection. These parts should be inspected as closely as possible to prevent failure at a later date.

Before disassembly of an engine is started, the applicable technical instructions should be checked in order to confirm the scope of repair necessary. Disassembly and repairs of an engine should never be attempted until complete familiarization is attained with the step-by-step procedures and repair limits contained in the current technical publications, directives, etc., for the particular engine.

The engine should be properly supported to prevent overstressing of the parts being removed. In addition to properly supporting the engine, the alignment of parts being removed or installed is of the utmost importance.

Immediately upon removing each subassembly or individual part from the engine, transfer it to a parts rack and arrange it so as to protect the assembly or part from damage. In handling

subassemblies, provide proper covering and supports to protect shafts, gears, studs, or any projecting part from being bent, scratched, or otherwise damaged.

Care must be exercised to prevent the entrance of dirt and other foreign materials into the engine. Whenever practicable, temporary covers should be used to seal all openings in dismantled engines. The ends of all tubing removed should be covered. Extreme care must be taken not to lay carbon seals and plates on the sealing surfaces. Provide appropriate containers to hold each part separately until the time of reinstallation.

During disassembly, all parts and assemblies should be examined for cracks, scoring, and burning. The engine in general should be checked for indications of work incorrectly performed during any previous repairs or overhauls.

COMPRESSOR BLADES (J52)

Damaged compressor blades can be reworked not to exceed the limits set forth in the applicable technical instructions in order to remove the injury. Portions of blades which have sustained indentations, blade material compressed and raised edges, and injuries with a small radii or ragged edges, must be removed. Well rounded injuries to leading and trailing edges of airfoil not exceeding the limits specified in the applicable technical instructions are acceptable without rework. No attempt should be made to remove an injury by straightening. Repaired compressor blades must be inspected by dye check to insure that no cracks have developed in injured area. All surfaces must be smooth and all repairs well blended. No cracks are permitted in any area. Blades which are bowed or bent must be replaced. Whenever possible, any stoning and local rework of blades should be performed parallel to the length of the blade. (See fig. 8-1).

COMPRESSOR INLET GUIDE VANES (J52)

Damages to the vanes produced by foreign material impingement which do not reduce part thickness by more than 0.015 inch and do not crack or tear apart are acceptable without rework, provided that the damage has not resulted in surface stress concentration. Those injuries which give rise to deep, sharp indentations must be blended. If damage is immediately adjacent to fillet welds at the inner and outer ends of the vanes, special care must be exercised in blending. Allowable local reduction in the vane sheet thickness must not exceed 0.025 inch on the concave sides of the vanes after blending. Vane trailing edge cracks or tears must be removed, but only to a maximum depth of 0.125 inch.

COMBUSTION CHAMBER LINERS (J52)

Inspect combustion chamber liners for cracks by using dye penetrant or the fluorescent penetrant method of inspection. Cracks converging in such a manner that metal could subsequently break loose, and any loose, cracked, or damaged swirl vanes are cause for rejecting a liner. Liners having buckled areas in a weld seam or areas in excess of three-sixteenths inch wave that do not include the weld seam must be removed from service.

Combustion chamber liners may be continued in service when the following conditions exist: Cracks less than 0.750 inch long emanating from combustion airholes (no more than one per section). Radial or circumferential cracks less than 0.750 inch long extending from or around the crossover tubes or igniter plug bosses. Reuse of combustion liners exhibiting burning is permitted. Cracked deflectors must be reworked to remove cracked area by blending or cutting prior to reuse. Burning of the cooling louver must not exceed two tabs totally burned or a total area of two tabs per liner. (See fig. 8-2.)

COMBUSTION CHAMBER SUPPORT (J52)

Cracks in the combustion chamber support can be repaired by inert-gas fusion welding. Repairs must not result in distortion or misfit of parts at assembly. File out any hole that is distorted as a result of welding to restore it to the original configuration. The weld bead must be hand blended after welding. (See fig. 8-3.)

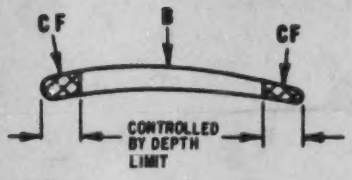
COMBUSTION CHAMBER INNER AND OUTER OUTLET DUCTS (J52)

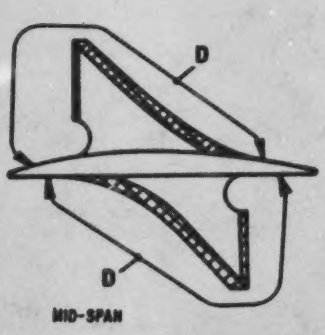
Operational cracks in the inner and outer outlet ducts up to 3 inches in length may be allowed to continue in service, provided there are no more than two cracks per duct. Cracks in excess of 3 inches and exceeding 75 percent of the entire circumference of the duct at the

MAXIMUM ALLOWABLE LIMITS

Blade Area		Stages 1 and 2
	A	1/4 x 3/8
	B	0.031D
	C	0.156D
	D	NONE
	E	0.031D
	F	0.031D

D=DEPTH





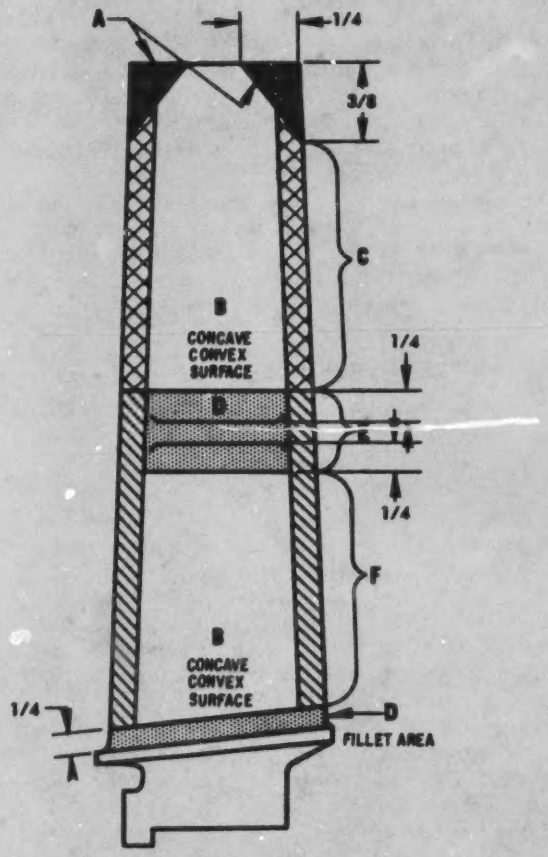


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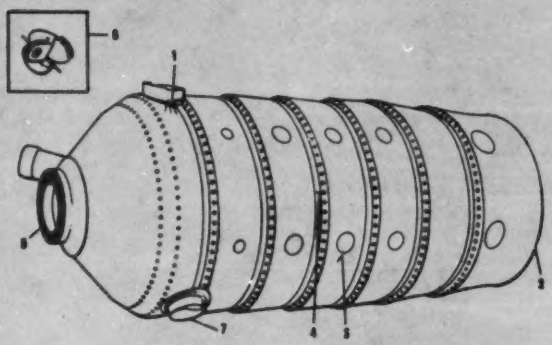
Figure 8-1.—Compressor blade repair limits (stages 1 and 2).

station must be repaired by gas fusion welding. When repairing a duct, use a silicon carbide grinding wheel, grinding a 90-degree Vee groove, 0.035-inch deep, for the entire length of the crack. It is permissible to remove some of the parent material when grinding. Importance of the depth is only to ascertain that the grinder removes all material from the crack. Repairs must not result in distortion or misfit of the parts at assembly. File out any hole that is distorted as a result of welding to restore it to the original configuration. (See fig. 8-4).

TURBINE BLADES

Turbine blades with nicks or dents in the airfoil within 0.500 inch of either shroud end or root platform may be blended if the damage



AD. 241

1. Cracks up to 0.750 inch, radial or circumferential, or minor buckling are permitted.
2. Out of roundness up to 0.500 inch is permitted.
3. Up to 0.750-inch crack permissible (no more than one per segment).
4. Cracks detectable from OD are not acceptable. Minor cracking from the cooling air louver slots detectable from ID only is acceptable.
5. Cracks or looseness not acceptable.
6. Mounting lug radial or circumferential cracks not acceptable.
7. If 0.005 inch clearance can be maintained between the male and female tubes when assembled, the out of round of the crossover tube is acceptable.

Figure 8-2.—Combustion chamber liner limits.

is not detectable on the opposite side of the airfoil from which they were struck, and repair will not reduce the local airfoil thickness by more than 0.005 inch or the chord length by more than 0.010 inch. Remove nicks and dents by using files and stones, ending with a fine stone.

Turbine blades which require replacement must be replaced by a pair of matched blades. Blades must be assembled so that any two blades 180 degrees apart will bear the same "moment" classification letter. It is permissible to replace a complete set of turbine blades. If a complete set is replaced it is necessary only that matching blades be located 180 degrees apart. If less than a complete set is being replaced it is mandatory to reinstall any removed blades in their original locations.

COMBUSTION CHAMBERS LINERS INSPECTION (J57)

Inspect the interior of the combustion liners for excess weld material expelled from the circumferential welded seams.

To prevent future damage to the turbine blades, remove weld material or slag which is not thoroughly fused to the basic material of the combustion liner. Use a hand pick fabricated from a three-sixteenths steel welding rod or other suitable material.

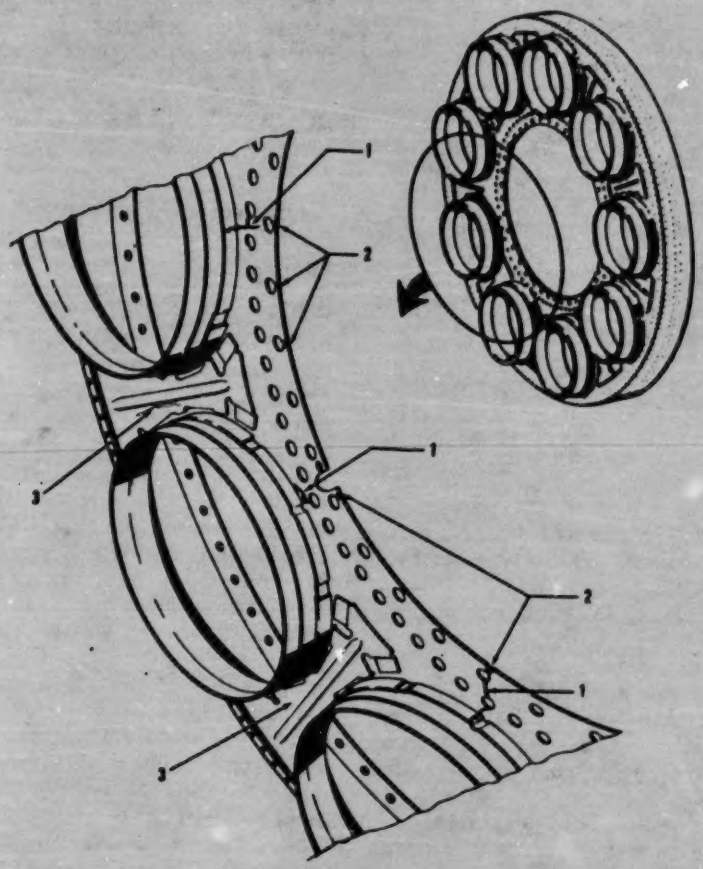
The purpose of the following inspection is to provide information relative to the service-ability of combustion chamber liner weldments which have sustained physical deterioration resulting from engine operation. These limitations on such deteriorations are based on the fact that the combustion chambers must demonstrate satisfactory serviceability during the intervening period of operations between successive periodic inspections of the parts, which periods are established for each engine model.

While certain types of cracking and burning deterioration resulting from thermal stresses may be found after periods of operation, the progress of such discrepancies with further operation is usually negligible, since the deterioration that has been produced by thermal stresses, in effect, relieves the original stress condition. Therefore, the majority of discrepancies occur in the early stages of operation and further progression may be expected to proceed at a greatly reduced, if not negligible, rate. It is usually normal to observe a recurrence of a given type of deterioration from chamber to chamber in a given engine.

The following paragraphs describe some typical discrepancies found on combustion chamber weldments. Figure 8-5 shows a combustion chamber liner with the components listed.

Cracks

Combustion chamber weldments should be replaced if two cracks are found progressing from a free edge such that their meeting is imminent and could allow a piece of metal (that could cause turbine damage) to break loose.



AD. 242

1. Maximum length of crack 2 inches.
2. Cracks, maximum of 33 percent and not more than three adjacent holes.
3. Only one crack per section permitted and it must be welded.

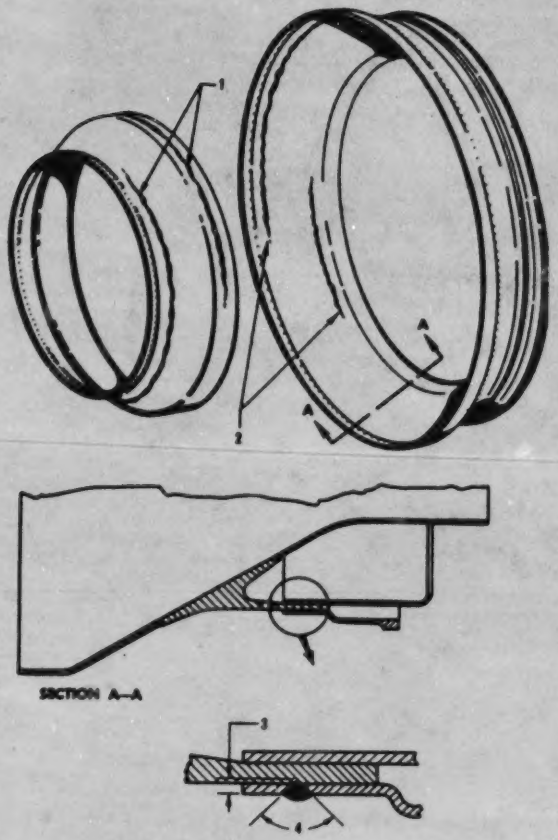
Figure 8-3.—Combustion chamber support limits.

Localized buckling and cracking of the inner diameter of the swirl cups starting at the center tube tabs are acceptable. In addition, small peripheral cracks in the fusion weld, which joins the cups and the tabs, are acceptable provided that the cracks are not expected to cause a piece of metal to break loose prior to the next periodic inspection of the liners.

Cracks found at the junction of the swirl cup outer diamaters and the attaching tabs are considered acceptable if pieces of metal would not be expected to break loose prior to the next periodic inspection.

Burned or Buckled Areas

Localized areas may be found wherein the parts have been heated to an extent to consume or buckle small portions of the chamber. Such parts are considered acceptable if the burning of the part has not progressed into an adjacent welded area or to an extent to weaken the structure or the liner weldment.



AD. 243

1. Cracks, inner duct.
2. Cracks, outer duct.
3. 0.035 inch.
4. 90 degrees.

Figure 8-4.—Combustion chamber inner and outer outlet ducts.

Buckling and cracking of the combustion chamber outer wall in the vicinity of the crossover tubes are acceptable.

Moderate buckling and associated cracks are acceptable in the plane of the last row of cooling holes. More severe buckling that produces a pronounced shortening or tilting of the rear and of the center tube is cause for rejection.

FUEL NOZZLE INSPECTION

With the combustion case open and the weldments out, the fuel manifold is accessible for inspection and repair. If any nozzles are replaced or any evidence of fuel leakage is found in the manifold, a pressure check should be performed after repairs are completed.

After completion of the pressure check, disconnect the quick disconnectors from the adapter on the fuel inlet pad of the manifold and drain the fluid into a suitable container. While the fluid is draining, remove the nozzle clamps from top to bottom. Remove the test adapter from the inlet pad of the adapter.

After installation of the pressurizing and dump valve, another pressure check must be performed.

TURBINE BLADE AND TURBINE NOZZLE VANE INSPECTION (J57)

After opening the combustion chambers and removal of the combustion liners, the first stage turbine blades and turbine nozzle vanes can be inspected. The blade limits specified in the Maintenance Instructions Manual should be adhered to. Figure 8-6 shows where cracks usually occur on the turbine nozzle assembly. Slight nicks and dents are permissible, provided the depth of injury on the airfoil is within limits.

With the afterburner removed, the third stage turbine can be inspected for any cracks or evidence of blade stretch. The third stage nozzle can also be inspected with a strong light by looking through the third stage turbine. Any damage to the hot section that requires removal of the turbine must be sent to a higher maintenance activity to be repaired or scrapped.

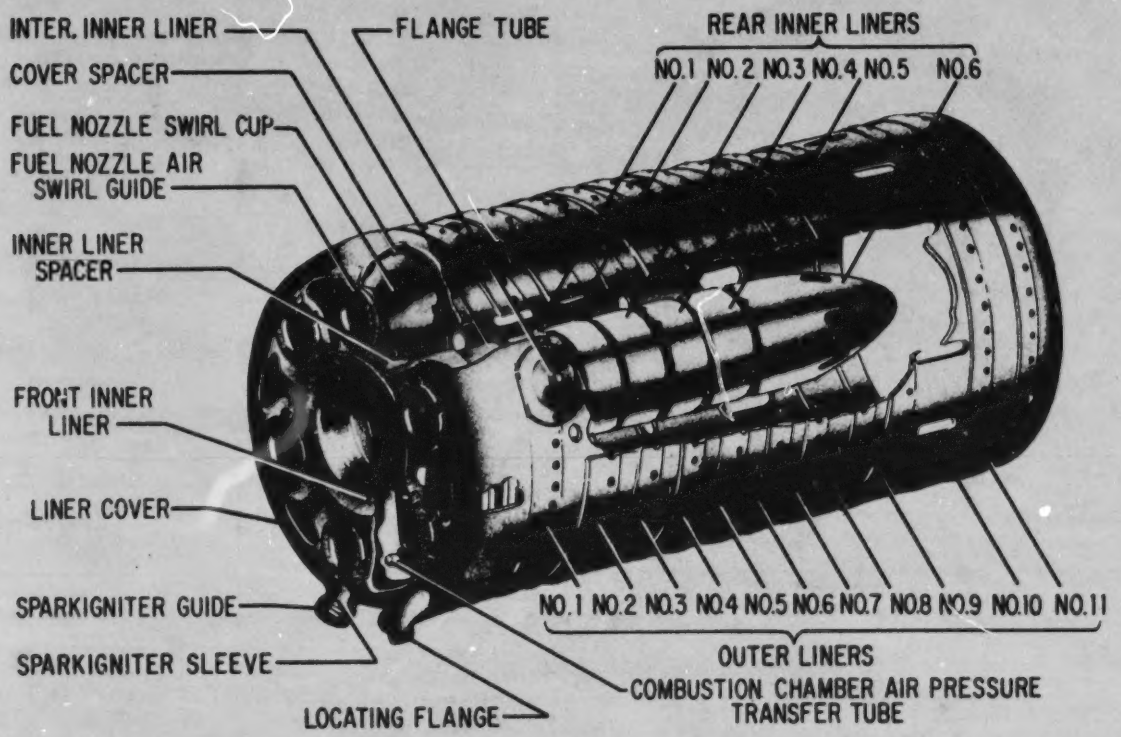
SIXTEENTH STAGE COMPRESSOR VANE INSPECTION (J57)

The 16th stage compressor vanes may be inspected with a strong light by looking forward, after the combustion chambers are removed.

Sixteenth stage compressor vanes are of two types, the single row and the double row. The general information is the same as for other compressor vanes.

COMBUSTION LINERS (J79)

The J79 differs from the J57 in that it uses 10 combustion liners. The combustion liners of the J79 are situated between an inner and outer combustion casing. Each combustion liner consists of three parts riveted together. They are



AD. 244

Figure 8-5.—Combustion chamber liner component nomenclature (J57).

referred to as the inner liner, outer liner, and rear liner. The outer liner incorporates a snout which scoops compressor discharge air into the liner. Vanes in the snout distribute air uniformly around the dome of the inner liner.

The No. 4 liner has a spark plug hole through the outer and inner liners. The liners are joined together by cross ignition tubes.

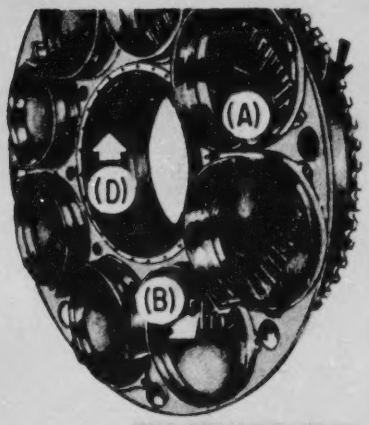
The combustion liners can be removed from the engine without removing the combustion assembly. If both halves of the outer combustion casing are removed, the combustion liners can be removed or replaced.

Scratches in the combustion liners can be buffed out to a depth not to exceed one-half of the parent metal thickness. Dents in the inner, outer, and rear liners can be straightened to as near the original contour as possible by hammering. Cracks in the inner, outer, and rear liners can be repaired by welding. Combustion liners must be replaced if they have wear at the alining holes, eroded or burned areas at the nozzle port, igniter plug holes, and thimble projections (See fig. 8-7.)

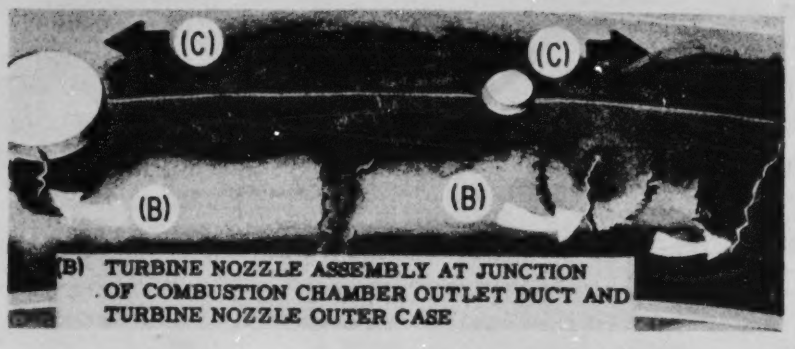
FUEL NOZZLES (J79)

The fuel nozzles, one in each combustion liner, produce an effective spray throughout a wide range of fuel flow variations. A shroud on the nozzle tip directs a small quantity of air across the nozzle face to reduce carbon deposits and distortion of the nozzle face.

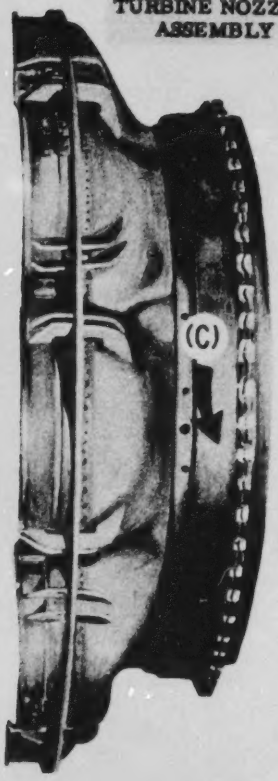
Fuel nozzles must be replaced if they have excessive carbon buildup, more than six radial cracks in the shroud, and cracks in the body, inlet fitting, and spray orifice. (See fig. 8-8.)

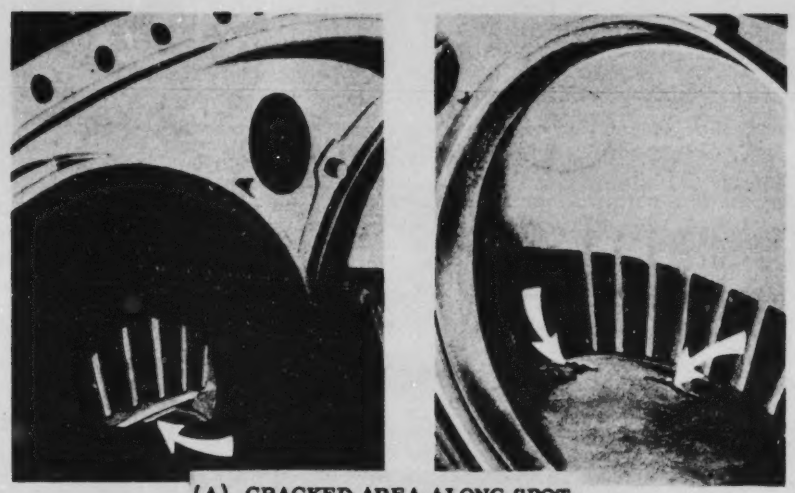


TURBINE NOZZLE ASSEMBLY

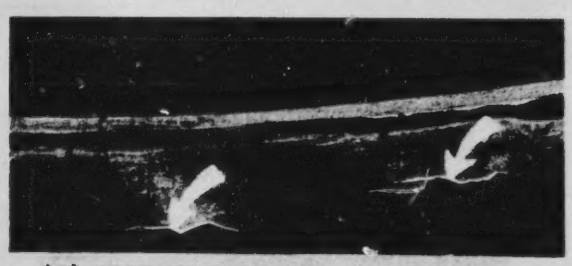


(B) TURBINE NOZZLE ASSEMBLY AT JUNCTION OF COMBUSTION CHAMBER OUTLET DUCT AND TURBINE NOZZLE OUTER CASE





(A) CRACKED AREA ALONG SPOT WELD LINE ON INNER DUCT



(A) SPOT WELD CRACKS ON INNER DUCT

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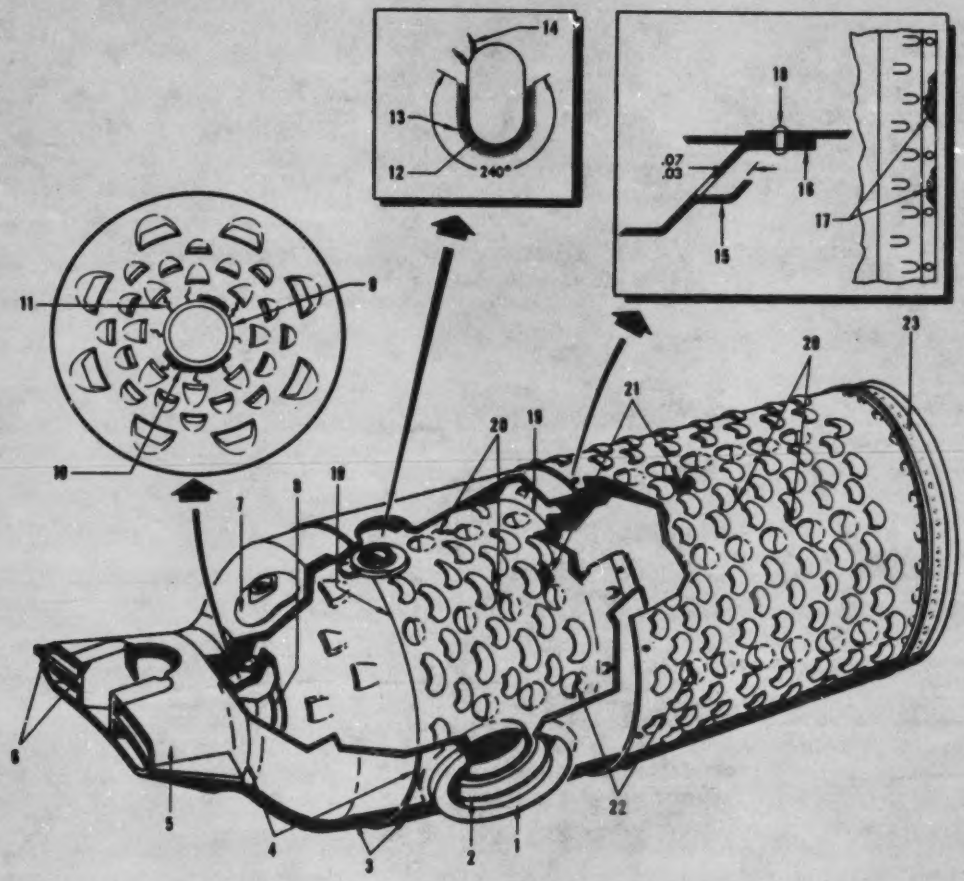
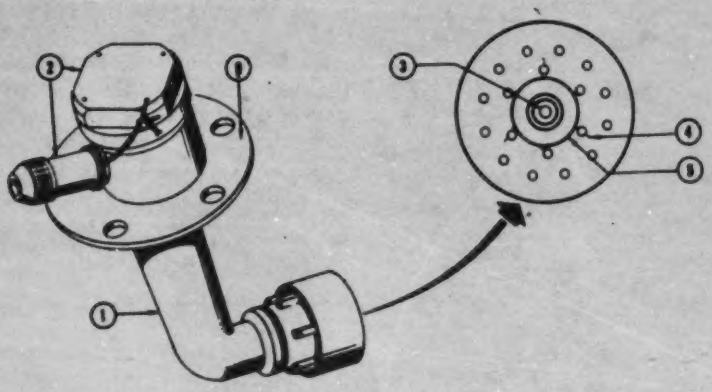
Figure 8-6.—Turbine nozzle assembly.



AD. 245

1. Flange, cross ignition.
2. Cross ignition flange weld.
3. Outer liner body.
4. Outer liner seam, or spot weld.
5. Air inlet snout.
6. Snout welds.
7. Mounting pin boss.
8. Fuel nozzle outer bushing welds.
9. Fuel nozzle port.
10. Eroded or burned areas at fuel nozzle port.
11. Cracks, fuel nozzle port to louvers.
12. Spark plug holes (inner liner).
13. Downstream burning at spark plug holes.
14. Cracks, spark plug holes.
15. Baffle hook louver.
16. Rear edge of inner and outer liners.
17. Eroded or burned areas.
18. Rivets.
19. Inner liner butt welds.
20. Cracks in louvers and thimbles.
21. Missing pieces, inner and rear liners.
22. Eroded and burned thimble projections.
23. Aft flange of rear liner.

Figure 8-7.—Combustion liner (J79).



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1. Body.
2. Cap and inlet fitting.
3. Spray orifice.
4. Shroud crack.
5. Shroud indentation.
6. Flange.

Figure 8-8.—Fuel nozzle (J79)

OUTER COMBUSTION CASING (J79)

The outer combustion casing is split on the horizontal line to permit removal of half of the casing for inspection and removal of the combustion liners. The upper half contains a port at the 12 o'clock position for extraction of anti-icing air. The lower half contains two spark plug bosses—the one at the No. 4 liner is used—and a combustion system drain. A port near the rear flange allows air to flow from the combustion casing to the pilot burner. A locking strip, which fits along the inside of the horizontal flange, strengthens the flange and prevents air leakage.

The outer combustion casing must be replaced if more than three cracks are present in the flange or the body has any axial cracks. Circumferential cracks in the body and longitudinal cracks in the boss weld not over 2 inches long may be repaired by welding. (See fig. 8-9.)

The outer combustion casing is an assembly of matched halves; therefore, the entire casing must be replaced when the replacement of either half is necessary.

INNER COMBUSTION CASING (J79)

The inner casing is an internally stiffened cylinder that bolts between the compressor rear frame and the transition liner and the first stage turbine nozzle. It absorbs the torque developed on the turbine nozzle and confines the combustion airflow to an annular passage around the liners. Holes near the front of the casing permit air to flow into the chamber around the turbine shaft to cool the shaft.

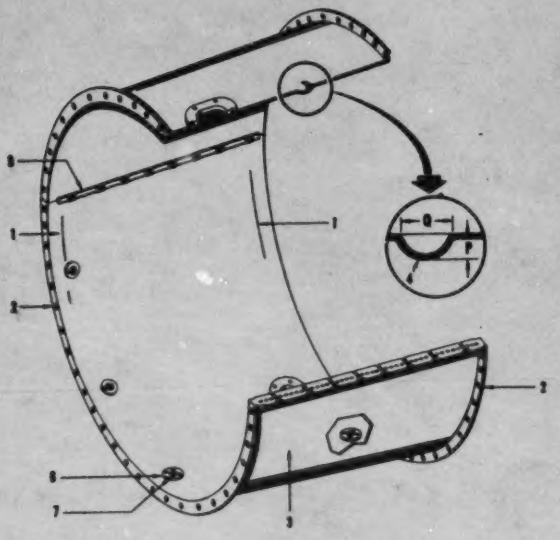
Cracks in the body of the inner combustion casing can be repaired by welding, provided the maximum cumulative length of the repair area does not exceed 2 inches. The inner combustion casing must be replaced if more than one crack extends outward from a bolthole. Dents and buckles in the casing are not repairable and the casing must be replaced.

TRANSITION LINER

The transition liner provides a ring of 10 oval inlet ports and an annular exit which has an area approximately one-half that of the total area of the 10 inlets to accelerate the gases into the first stage nozzle. The liner is supported by the rear flange of the inner combustion casing and is held in place by five pin-bolts near the rear flange of the inner combustion casing.

The inlet ports of the transition liner support the rear end of the combustion liners. Small louvers between the inlet ports admit cooling air.

Buckles, bulges, and cracks in the transition liner may be repaired by welding; however, any indication of burning or erosion on the liner body is not permissible. The transition liner must be



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1. Flange weld.
2. Bolthole.
3. Body.
4. Body dents.
5. Locking strip.
6. Boss weld.
7. Boss thread.

Figure 8-9.—Outer combustion casing.

replaced and the old liner returned to supply to be repaired at a higher maintenance facility or scrapped. (See fig. 8-10.)

NOTE: Upon completion of any of the foregoing discrepancies the necessary paper work must be completed in accordance with OpNav Instruction 4790.2 (Series). This may be in the form of a Maintenance Action Form (MAF), Unsatisfactory Material/Condition Report (UR), Technical Directive Compliance Form (TDC) or a Work Request. It may be necessary to complete as many as three of these forms upon completion of a job.

The importance of proper completion of these forms cannot be overemphasized. Proper uses of these forms are described in detail in Military Requirements for Petty Officer 1 & C, NavPers 10057-C. Preparation and completion of the forms are covered in Military Requirements for Petty Officer, 3 & 2, NavPers 10056-C, and in OpNav Instruction 4790.2.

INTERMEDIATE MAINTENANCE ACTIVITY

Intermediate maintenance applies to those maintenance functions normally performed in centrally located facilities for support of operating units. These facilities are designated Aircraft Intermediate Maintenance Departments (AIMD).

The primary purpose of the Intermediate level maintenance activity is to support and supplement the work of Organizational maintenance activities. Squadron personnel assigned to the Intermediate level activity, ashore or afloat, are assigned to perform the total work (within their skills) of the Intermediate activity and not just the work related to support of the squadron from which they have been assigned.

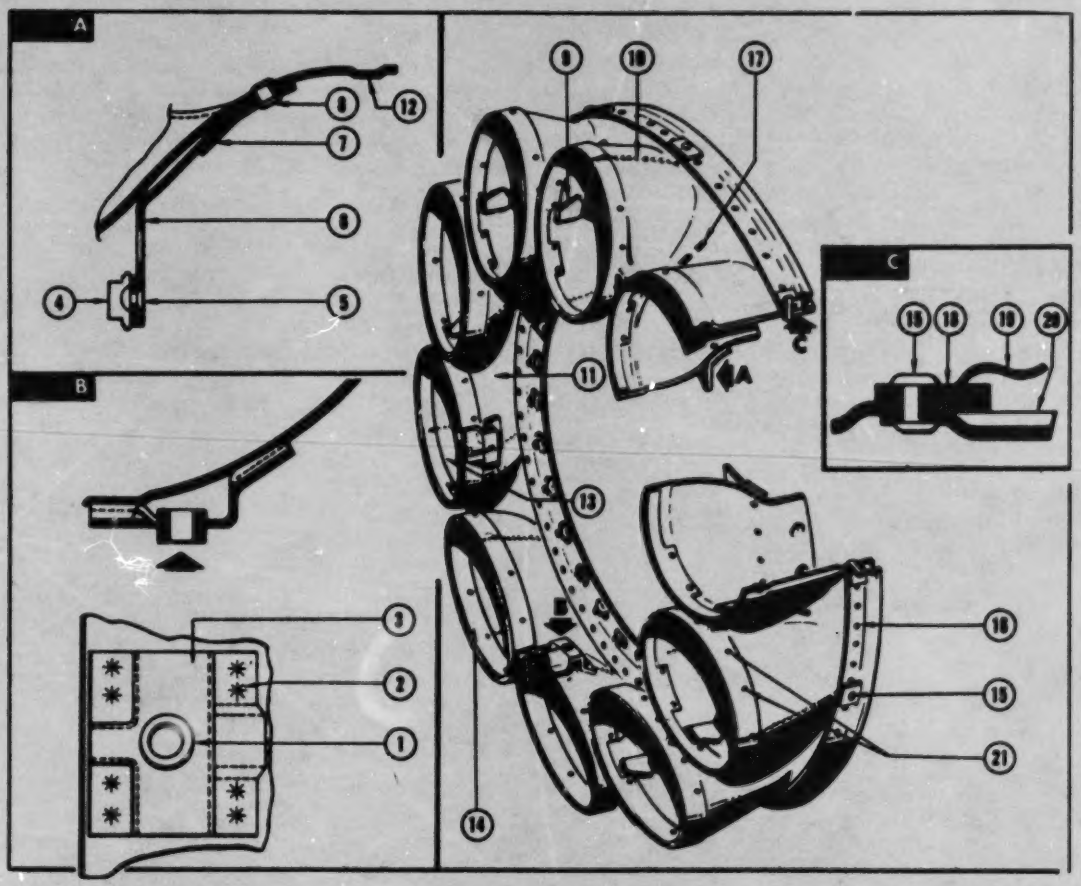
The following paragraphs cover some of the procedures and equipment used in an Intermediate maintenance activity. The Chief and First Class Aviation Machinist's Mate J will be using some of this equipment and should be familiar with its operation.

An engine that has been replaced due to a discrepancy beyond the capability of an Organizational maintenance activity is delivered by supply to the AIMD for repairs. After the engine is repaired by AIMD, it must be taken to a test cell or test area to be test run and calibrated.

After completion of repairs, an engine must be transferred from the workstand to a trailer to be transported to the test area. The following procedure may be used when transferring an engine (J79, for example) to a trailer.

When the engine is ready to be removed from the workstand, remove all fixtures and supports. Install the lift adapter on the 12 o'clock pad of the compressor front frame, and install the stabilizer bar underneath the engine. Aline, level, and lock together the trailer and the workstand. Release the roller clamp handles, roll the engine onto the trailer, and tighten the roller clamp handles. Install the upper front frame yoke assembly; then connect the support link of the upper yoke assembly to the forward holes of the lift adapter on top of the compressor front frame. The front frame is now supported at the 3, 9, and 12 o'clock positions, and the engine is now ready to go to the test area or cell.

If the engine is on a rollover stand, it must be lifted and placed on the trailer for transportation to the test area or cell. The only difference will be to lift the engine clear of the rollover stand, using the lift fixture. Remove



1. Bushing.
2. Spot welds.
3. Bracket.
4. Floating nut plate.
5. Rivet.
6. Stiffener ring.
7. Doubler.
8. Rivet.
9. Gusset weld.
10. Inner and outer liner welds.
11. Inner liner body.
12. Areas of contact with turbine nozzle.
13. Outer liner body.
14. Combustion liner mounting surface.
15. Rivet.
16. Rivet.
17. Hook louvers.
18. Stop plate.
19. Outer ring.
20. Rear insert.
21. Rivet.

Figure 8-10.—Transition liner (J79).

the rollover ring; then carefully lower the engine onto a trailer that has the adapter mounts in place. Secure the turbine frame thrust mounts first; then secure the front frame mounts to their adapters. Now the engine, supported at the 3 and 9 o'clock positions, is ready to be transported to the test area or test cell.

After transporting the engine to the test area or test cell, carefully aline, level, and lock the trailer to the test stand. Release the

roller clamp handles and roll the engine onto the test stand. Tighten the roller clamps and remove the trailer. Connect the draglinks to the adapter on the rear of the thrust mount as shown in figure 8-11.

Disconnect the front adapter from the adapter mounts so that the engine is supported from the 12 o'clock position at the front frame. Install the bellmouth and nose fairing. Loosen the roller clamp handles so that the rollers are free to move. Secure the handles with lockwire to keep them from tightening during engine operation. The draglinks restrain the engine during operation. The applicable technical instructions must be used to hook up the various test leads, hoses, and linkages to the engine.

INTERMEDIATE MAINTENANCE TURBOJET ENGINE TEST FACILITY

The test equipment is for use in an Intermediate maintenance turbojet engine test facility installation. The test facility is designed for service testing turbojet engines in accordance with procedures and manuals published by the Naval Air Systems Command.

The test equipment is capable of handling 30,000 pounds of jet thrust during performance tests. The test facility building configuration has an engine mass airflow capacity of 180 pounds per second, or approximately 17,000 pounds of thrust, including afterburner operation.

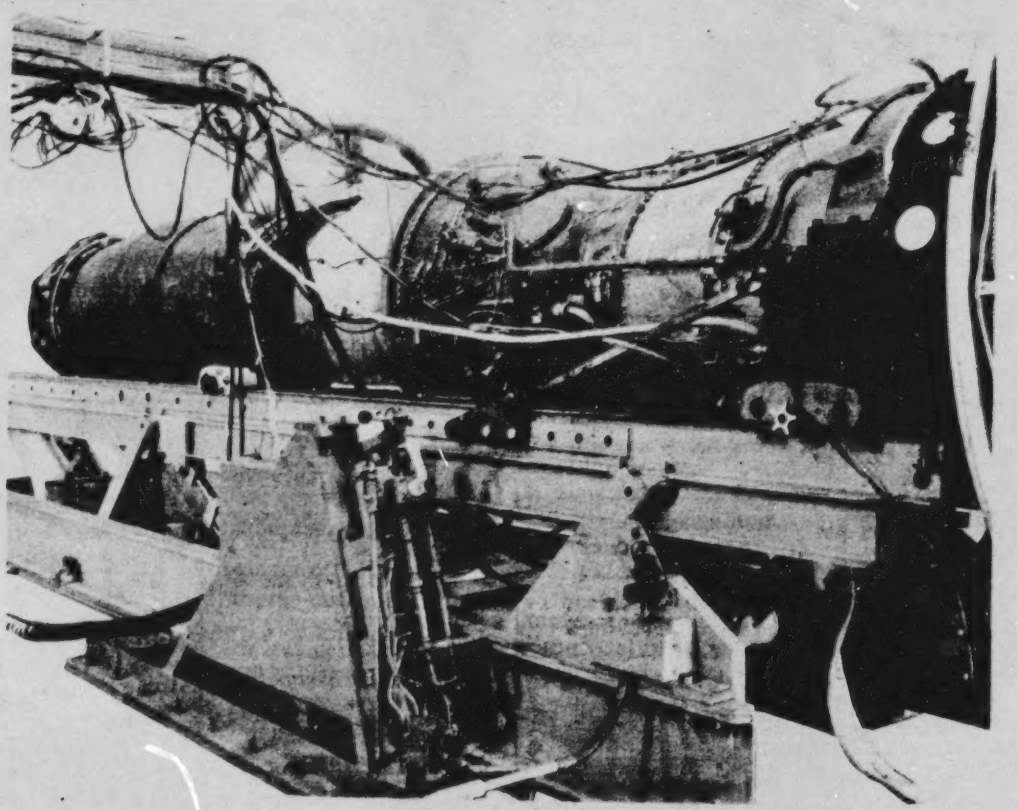


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Figure 8-11.—Thrust bed.

The complete test equipment consists of nine interconnected major assemblies. These assemblies are installed in the test facility building. The test facility building is constructed of reinforced concrete throughout. Removable concrete panels are provided in the primary intake and exhaust stack systems to permit airflow and acoustic expansion of the test facility to a 30,000-pound thrust capacity.

The test cell consists of horizontal primary and secondary air intake stacks, a vertical exhaust stack, an engineroom, and a spray-room. Immediately adjacent to the test cell is a one-story structure containing an engine control room, a pumproom, and a fuel filter room.

The pumproom contains a cooling water pump, an air compressor, a 28-volt d-c generator set, and a 115-volt, 400-Hz a-c generator set for operation of the test facility. In addition, the pumproom also contains batteries for operation of the CO_2 fire extinguishing system. The fuel filter room contains a fuel flow measuring package in addition to a fuel filter separator.

The test facility operates on the principle that the accumulation of sufficient data for comparison with known or desired optimum values, will satisfactorily indicate the relative service of an engine under test. To accomplish this result, engine performance and test cell environmental data are compared to standard day performance criteria for the engine model being tested. A multiplicity of controlling, sensing, and indicating systems are provided to accurately measure engine performance and test cell environmental conditions prevalent during the test.

Major Components

A brief discussion of the purpose of each of the major assemblies is given in the following paragraphs. System description and operating principles follow.

VARIABLE HEIGHT STAND ASSEMBLY.—The variable height stand assembly, or thrust bed, is utilized to support, restrain, and position the engine in the desired testing attitude. It is also used to transfer the engine from the trailer to the thrust bed. Included with the variable height stand are mounting rails for the engine, hydraulic controls, an air-hydraulic booster, hydraulic lift cylinders, a pivoting mechanism, and provisions for mounting thrust-bearing equipment.

The mounting rails (thrust bed) are reinforced and drilled to accommodate clamps which locate and restrain the engine in its optimum testing position. A link rod couples each clamp to an eye on the appropriate engine maintenance and test adapter. The thrust bed is suspended on four flexure plates, which permit the thrust bed load beam to actuate the thrust measuring system.

Limit stops are provided on the load beam to prevent excessive movement of the thrust bed during engine installation and removal procedures. When the forward adjustable limit stop is utilized to completely limit movement of the thrust bed, the limit stop must be readjusted prior to engine operation to permit normal operation of the thrust measuring system. Through use of the hydraulic controls, the thrust bed can be raised or lowered to match the height of the trailer when rolling the engine onto the thrust bed or when positioning the engine so it can be operated on the required 5-foot centerline from the engine floor. The first stage augmenter orifice centerlines cross at approximately 5 feet above the floor.

ENGINE TEST CONNECTOR PANEL ASSEMBLY.—The engine test connector panel assembly (connector panel) is provided as a terminal board for interconnecting the engine with the test equipment.

CONTROL BOARD INSTRUMENT ASSEMBLY.—The control board instrument assembly (control board) provides for central control of the engine and the test equipment. The necessary indicating and recording instrumentation for monitoring engine and test facility conditions is located here. An operator can exercise complete control of the test facility from this control board.

EXHAUST AUGMENTER ASSEMBLY AND EXHAUST GAS COOLING SYSTEM ASSEMBLY.—The exhaust augmenter assembly (augmenter) and the exhaust gas cooling system assembly (exhaust cooling system) are provided to insure proper disposition of engine exhaust by controlling exhaust gas, flow characteristics, and temperature. These factors can be monitored, both manually and automatically, with the controls and instrumentation installed. For example, if exhaust stack temperatures in excess of a preset temperature are experienced during afterburner operation, the afterburner is automatically cut off by a latching relay. When this occurs, the afterburner cannot be relit until safe temperature conditions again prevail and the relay is reset. Provisions have been made for manually overriding the exhaust stack

temperature control system should it fail or otherwise prove inadequate.

The principle of automatic safety control is a built-in characteristic of test equipment. To accomplish this an interlock system has been provided for automatic engine shutdown or prevention of engine start whenever the following conditions prevail:

1. Inadequate water pressure to maintain exhaust gas cooling, except when bypassed by the WATER-FUEL INTERLOCK switch.
2. Thrust bed not locked and interlocked in height position.
3. Front door key not in control panel lock, or door unlocked without utilization of front door bypass switch and rear door key not inserted in control panel lock.
4. Primary air supply fire curtain not open.
5. CO_2 fire extinguishing system energized, either manually or automatically.
6. Electric power failure.
7. Systemwide loss of compressed air supply.

FUEL SYSTEM MONITORING ASSEMBLY.—The fuel system monitoring assembly (fuel system) consists of the devices required for fuel filtration, flow and specific gravity measurement, and flow control.

ENGINE OIL RESERVOIR AND ENGINE AUXILIARY LUBRICATING OIL COOLING SYSTEM COMPONENT ASSEMBLY.—The engine oil reservoir and engine auxiliary lubricating oil cooling system component assembly (lubricating system) provides a 20-gallon engine oil reservoir and an auxiliary means of cooling engine oil to a controlled temperature.

COMPRESSED AIR COMPONENT ASSEMBLY.—The compressed air component assembly (compressed air system) provides pneumatic power, air system hardware, and pneumatically operated controls and actuating cylinders necessary for remote control of numerous devices throughout the test facility.

INTERCOMMUNICATION SYSTEM.—The intercommunication system has been provided to facilitate communication between the control room and the test cell. As installed, the system consists of a master station in the control room and of one remote station each at the test cell observation port and the test cell. The master station is designed to handle six additional remote stations, if required at some future time.

ELECTRIC POWER AND OTHER TEST FACILITY FEATURES.—Three primary sources of electric power are provided for the test facility. They are as follows:

1. Main service to facility: 120/208-volt a-c, 3-phase, 60-Hz, 4-wire.
2. Motor-driven generator test set: 28-volt d-c.
3. Motor-alternator test set: 115-volt a-c, 1-phase, 400-Hz.

Electric power, developed by any test engine equipped with an engine-driven alternator, is not utilized for test purposes. If required by the applicable engine test instructions, arrangements have been made for application of a token 5-kva alternator load by means of a water-cooled load bank, consisting of immersion heater elements.

Various components are provided to support or supplement the test equipment. Major items of this sort are as follows: facility fuel supply tanks; fuel pumps and motors; water pump controls, valves, etc., motor control center and associated electrical equipment; 115-volt a-c, 1-phase, 60-Hz lighting switch panel; and CO_2 fire extinguishing system. Engine harness and hookups between engine and connector panel, as well as special test items, are the responsibility of the using activity.

Test Equipment System

The major assemblies of test equipment discussed in the above paragraphs are integrated into the total functioning and operation of the test facility. For example, numerous test equipment items are located in, or integrated with, portions of the fire extinguishing, fuel, water supply, and electrical systems which are, in turn, part of the test facility. For the purpose of clarifying the functioning of the test equipment major assemblies and their relationship to operation of the test facility, the assemblies are considered to be part of the following systems:

1. Thrust bed positioning system.
2. Thrust measuring system.
3. Engine test connector panel system.
4. Control board system.
5. Interlock system.
6. Exhaust augmenter system.
7. Exhaust gas cooling system.
8. Fuel system.

9. Engine lubricating system.
10. Compressed air system.
11. Intercommunication system.
12. Engine starting and ignition system.
13. Electrical power system.
14. CO_2 system.

THRUST BED POSITIONING SYSTEM.—The thrust bed positioning system is essentially a pneumatic-powered, hydraulic-oil-driven device capable of raising and lowering the test engine to any attitude within operating range. Operating controls are mounted on the left front A-frame of the thrust bed. (See fig. 8-11.)

In addition to supplying lifting force for height positioning of the thrust bed, oil pressure is used to drive the calibration cell cylinder whenever controlled thrust pressure is required.

THRUST MEASURING SYSTEM.—The thrust measuring system becomes operative when the thrust button is acted against by the load cell as a result of slight forward motion of the engine under power. If desired, the load cell may be preloaded by the preload unit. As thrust is developed by the engine, the pressure between the button and the cell produces an electric potential within the cell. The electric current thus established is connected to the thrust measuring circuit box, where it is amplified sufficiently to power the thrust indicator, which is calibrated to read directly in pounds of engine thrust.

ENGINE TEST CONNECTOR PANEL SYSTEM.—The engine test connector panel system contains 75 essential connectors, fittings, etc., for interconnecting the test engine, control board, and the remaining test equipment. High and low-pressure quick-disconnect fittings (selfsealing) for pressure lines and capped electrical fittings for electrical lines are provided.

CONTROL BOARD INSTRUMENT SYSTEM.—The control board instrument system consists of four panels designated as Panel A, Panel B, Panel C, and Panel D. (See fig. 8-12.)

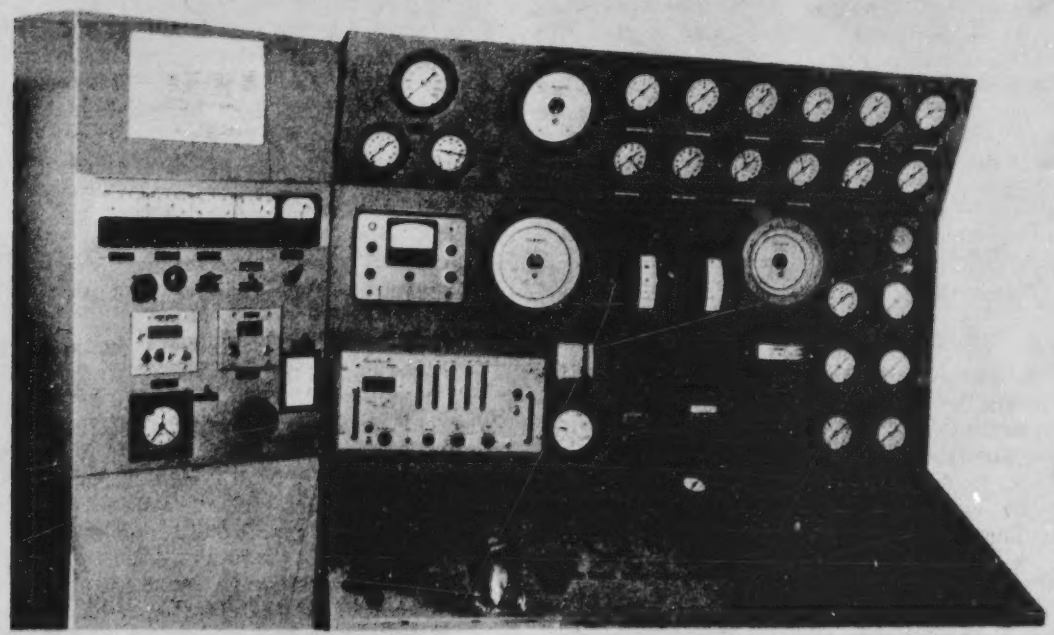

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Figure 8-12.—Control board.

The panels contain instruments and control components required to properly operate the test equipment to functionally test turbojet engines.

The electronic counter is an instrument designed to count specific events during variable intervals of time. As installed on the control board, it is used to indicate engine rotor(s) revolutions per minute.

INTERLOCK SYSTEM.—The interlock system is a simple series circuit consisting of manual and automatic switches, relays, and fuses.

An electric-motor-driven test generator provides all 28-volt d-c power used by the interlock system and the test equipment. It is started with a 28-volt, d-c motor-generator set switch, which opens and closes the main relay of the generator output line. The 28-volt engine master switch is the master input switch for the 28-volt system, including the interlock system. When this switch is raised to the ON position, its mating green pilot light is illuminated and engine master relay is energized. Power is then available at the 28-volt engine control switch, having arrived via the closed contacts of a normally open relay.

NOTE: All ON and OFF switches installed on the control board are positioned so that their respective ON positions in relation to the lower edge of the applicable panel are established with the toggle raised.

Control point No. 1 consists of a CO_2 pressure switch and mating green pilot light. The switch is a manual reset type, remotely located at the connector panel in the test cell and is programmed to seek the OFF position whenever the test cell of the CO_2 fire extinguishing system is energized manually or automatically.

If the pressure switch contacts are broken, they must be manually reset to the ON position before the interlock system circuit can be completed.

Control point No. 2 consists of front door key operated switch and two mating pilot lights. The key which operates the switch is the key locking the front door of the test cell; this key cannot be removed from the door lock mechanism until the door is locked.

Before the interlock system can be energized via the switch, the key from the front door must be removed and brought to the control room, for use with the switch. The two mating pilot lights indicate the key switch position: green for CLOSED and red for OPEN.

Control point No. 3 consists of front door bypass switch and mating red pilot light. This switch is provided to permit removal of the front door key from the switch at control point No. 2. The key cannot be removed without placing the switch in the OPEN position so that the key may be used to open the front door when it is necessary for authorized personnel to attend to the engine or test equipment during periods of engine operation.

EXHAUST AUGMENTER SYSTEM.—The exhaust augmenter system consists chiefly of two stages. Both stages are adjustable to meet specific engine exhaust conditions.

The first stage exhaust augmenter is located in the forward test cell wall of the sprayroom. The horizontal centerline of this and the second stage is approximately 5 feet above the test cell floor. The first stage augmenter receives the exhaust discharge of the test engine and by venturi action tends to draw such exhaust to the second stage augmenter in the sprayroom. Included in the first stage is the first stage augmenter spray ring, which is controlled manually from the control board.

The size of the first stage augmenter orifice and the distance from the plane of the engine exhaust exit nozzle to the mount of the insert should be correlated for each engine model to obtain true engine performance and proper control of secondary airflow. Improper sizing and positioning of the first stage augmenter may result in:

1. Excessive turbulence in the region of the exit nozzle.
2. Excessive buildup of exhaust back-pressure.
3. An increase in exhaust gas temperature.
4. Loss of thrust.
5. Insufficient or excessive secondary airflow. (Excessive secondary airflow produces ram drag across the engine; and in conjunction with operation of nigh thrust engines, an excessive test cell depression results.)

The second stage exhaust augmenter is located in the sprayroom. A movable collector section is provided along with a flat orifice plate. Movement of the collector section, in and out of a lateral diffusing vane section, and the indexing of the orifice plate, afford quantity adjustment of the tertiary airflow from the secondary air intake stack through the second stage augmenter. The lateral diffusing vanes are water cooled and afford additional exhaust gas cooling. Discharged exhaust gases mixed with spray water and

secondary tertiary air, pass from the second stage augmenter into upward diffusing vanes located at the base of the exhaust stack and upward, and out the exhaust stack.

EXHAUST GAS COOLING SYSTEM.—The exhaust gas cooling system is composed of the following basic, series-connected components:

1. Water supply.
2. Pump No. 1.
3. Shutoff valve.
4. Water heater tank.
5. Bottom header of lateral diffuser.
6. Exhaust gas cooling and diffusing vanes.
7. No. 1, 2, 3, and 4 spray ring air cylinder actuated valves.
8. No. 1, 2, 3, and 4 spray rings.

The exhaust gas cooling system is supplied by a single water pump; however, most of the equipment necessary for a future two-pump supply system has been incorporated to facilitate installation of such a system, if required. This equipment is discussed in the overall explanation of the exhaust gas cooling system. The overall explanation also includes any equipment not currently installed but required for a two-pump system, as well as any features specifically resulting from the current dual system with only one pump supplied. With only one water pump, for example, there is insufficient capacity to flood No. 3 and No. 4 spray rings; therefore, these rings and the pump have been made inoperative.

FUEL SYSTEM.—The fuel system (fig. 8-13) consists chiefly of two 10,000-gallon underground fuel tanks, two fuel pumps, two motor-driven fuel line valves, the fuel system monitoring assembly, and various controls and pilot lights at the control board. The fuel system is interlocked to the basic interlock system, to the CO_2 fire extinguishing system, and to the exhaust gas cooling system.

ENGINE LUBRICATING SYSTEM.—The engine lubricating system consists chiefly of two major component assemblies; the engine oil reservoir system and the engine auxiliary lubricating oil cooling system.

The engine oil reservoir system comprises a 20-gallon tank equipped with suitable fittings, a sight gage, and breather vent. The engine lubricating oil is supplied from the storage tank, via the oil outlet to the engine lubricating system and back to the tank, via the oil inlet. The amount of oil in the tank can be readily determined by observing the oil level in the sight

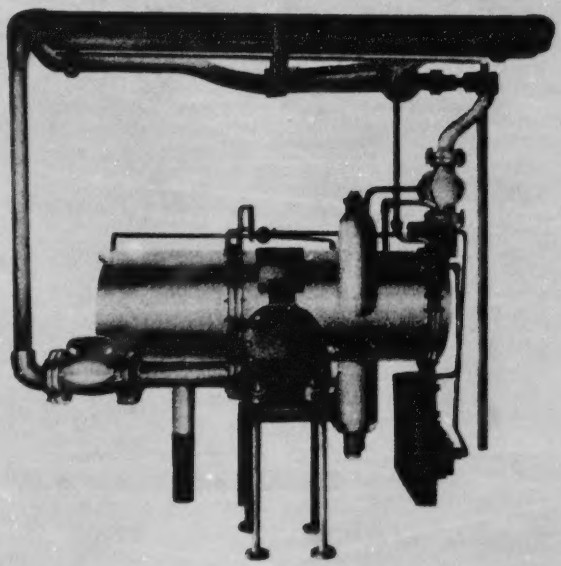

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Figure 8-13.—Fuel system components.

gage. The storage tank is located at an extension of the connector panel, in the test cell.

The auxiliary lubricating oil cooling system is provided for use as required by specific engines. (Refer to applicable engine test instructions.) It consists of an oil temperature regulator valve, a heat exchanger, and suitable plumbing. Water via the oil temperature regulator valve passes through the cooling elements of the lubricating oil heat exchanger to cool the engine oil circulating through the exchanger through the oil inlet and out to the engine through the oil outlet. The temperature of the oil returned to the engine, is sensed by the oil temperature regulator valve via a sensing bulb installed in the heat exchanger oil line. The oil temperature regulator reacts to the bulb signal by positioning a poppet valve to either increase or decrease waterflow through the heat exchanger to maintain the oil outlet temperature between proper limits. The oil temperature regulator is provided with a handwheel so that the temperature range may be adjusted if required to maintain outlet oil temperature within the allowable range. The

water utilized for cooling the engine lubricating oil flows from the main water supply system to the load bank water tank (containing heating elements) and then to the oil temperature regulator valve.

COMPRESSED AIR SYSTEM.—The air compressor (a two-stage, air cooled, electric-motor-driven type) is located in the pumproom and is controlled by a switch located on the master control center in the control room. Two plug-in outlets supply unregulated compressed air for test cell utility purposes as required. Air filtration and partial dehydration are accomplished by two float type air filters for two main branch supply lines. The pressure to each branch line is controlled by two manually set air pressure regulators. Beyond the pressure regulators the air system branches off to the various control components for other major systems, such as fuel system, exhaust gas cooling system, etc.

INTERCOMMUNICATION SYSTEM.—The intercommunication system consists of an eight-station intercom master in the control room, a suitable amplifying system, and two remote stations equipped with trumpets and microphones. The six spare station switches at the master control are not used as installed. The master unit is equipped with a volume control, a push-to-talk button, and a push-to-talk lock button. Remote stations are equipped with push-to-talk buttons only. Station No. 1 is located in the test cell; station No. 2 is located at the test cell observation port.

ENGINE STARTING AND IGNITION SYSTEM.—The starting of a jet engine or any other type of gas turbine engine requires that the engine be rotated at speed that will provide sufficient air intake for the required fuel-air ratio, provisions for energizing the ignition system to fire the spark (igniter) plugs at the proper time, and that the engine be accelerated until the power developed by the turbine is adequate for self-sustained rotation. Initial rotation of the engine during starting may be accomplished by use of either an electrically operated starter motor or a compressed air-operated air turbine starter motor. The electric starter motor requires a source of d-c voltage, and the air turbine motor requires a source of compressed air.

ELECTRIC POWER SYSTEM.—The electric power system consists basically of two sources of power; electric-motor-driven alternator set, which provides 115-volt, 1-phase, 400-Hz power; and an electric-motor-driven test generator, which provides 28-volt, d-c power.

CO_2 SYSTEM.—The CO_2 fire control system for the test facility consists chiefly of a 2-ton CO_2 storage tank incorporating a refrigeration system to maintain the liquid carbon dioxide at the proper storage pressure; a handwheel-operated shutoff valve on the dip tube of the storage tank; pressure-operated control valves for quickly releasing the carbon dioxide; a piping system terminated in CO_2 discharge nozzles strategically located in the protected areas; and various controls, relays, thermostats, alarm gongs, spurt and flood pushbuttons, and pressure-operated switches. For complete fire control coverage, the CO_2 system is electrically linked to the interlock system and pressure linked to the main fuel line valve of the engine fuel supply.

The CO_2 storage tank is designed for a maximum working pressure and is equipped with a complete Freon (F-12) refrigeration system, automatically controlled by an internally mounted pressure switch. The refrigeration system maintains a nominal storage tank pressure. Since the pressure of carbon dioxide depends upon the temperature under storage, a refrigeration system is required. The storage tank is protected by a safety assembly consisting of a dual switching valve which, when in the normal position, places in service one auxiliary automatic refrigeration valve, one safety valve, and one frangible disk. The safety devices provide complete protection against abnormally high tank pressures. An abnormally high pressure usually results from power or compressor failure continuing over a period of several hours.

PORTABLE UNIVERSAL ENGINE RUNUP TEST SYSTEM

The engine runup test system (fig. 8-14) provides aircraft maintenance activities with a portable and universal system for operational and functional testing of turbojet engines. The equipment is designed for field or advanced base engine support.

The system performs the basic function of checking all engine performance characteristics against the engine manufacturer's operational parameters as approved by the Naval Air System Command. The stand displays engine temperatures; vibration; fuel metering; fuel flow pressures; thrust; lube oil temperature and pressure; compressor pressures; hydraulic oil

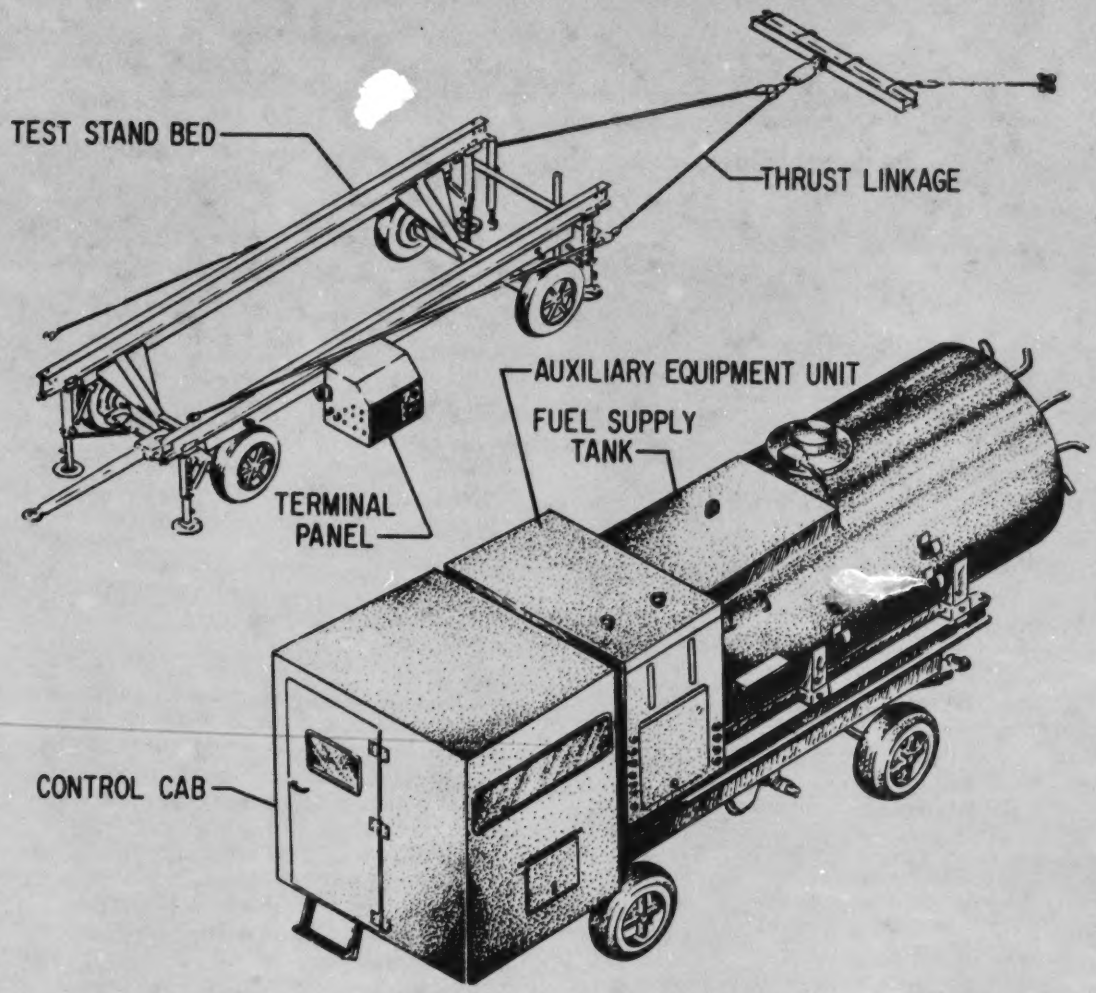

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Figure 8-14.—Portable universal engine runup test system.

pressure; anti-ice pressures; and positions such as nozzle and stator vane, throttle position, and turbine rpm. By using the appropriate engine control panel, the equipment will operate axial-flow engines.

NOTE: Centrifugal compressor engines may be tested at installations where the test stands have been adapted to accommodate these engines.

The test system (on stand) may be used at any site location which has been provided with adequate tiedowns (either concrete embedded or buried expansion anchors). Figure 8-15 shows an engine rig with a typical portable test stand.

PORTABLE TURBOJET ENGINE EXHAUST SOUND SUPPRESSOR

The portable exhaust sound suppressor for turbojet engines (fig. 8-16) attenuates exhaust noises of axial-flow turbojet engines, including afterburner configurations. The suppressor elevates and tilts to accommodate engines mounted

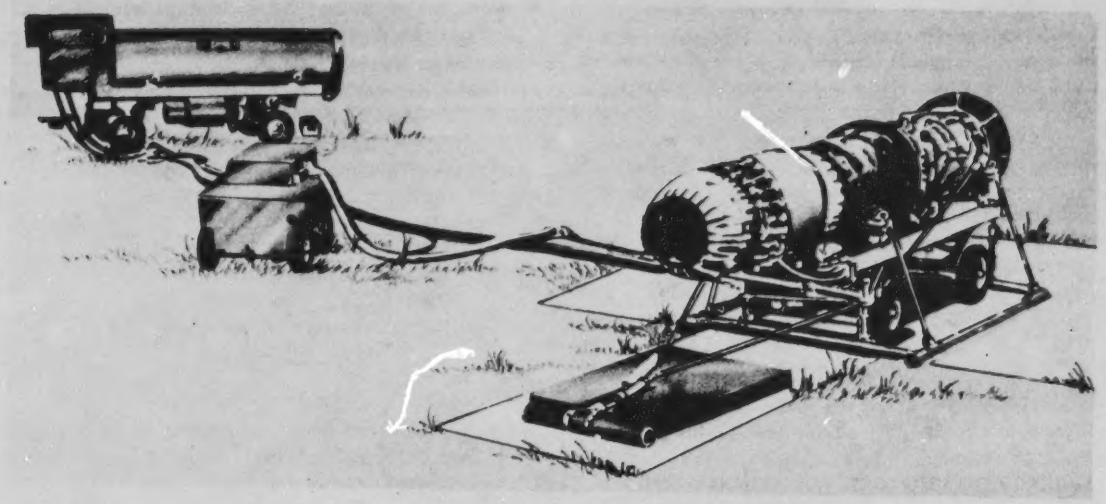

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Figure 8-15.—Engine test and runup system.

in various airframes. Shrouds or adapters to fit various airframe tail configurations are furnished, but will have to be adjusted before turnup. The suppressor has towing capabilities, but is restricted on speed. It also has tiedown provisions and should be secured before turning up an engine.

WORKSTAND ASSEMBLY MODEL 3110

The model 3110 workstand (fig. 8-17) is a 48-inch gage matching rail type unit designed to mate with rail type trailers for the roll transfer of the load along the rails. The workstand is used in the horizontal maintenance (assembly/disassembly) and storage of aircraft jet engines, airframe sections, and missiles.

UNIVERSAL, RAIL TYPE WORKSTAND

The universal, rail type workstand is used to support jet engines up to 10,000 pounds of weight during disassembly, rework, reassembly, and storage. The stand is also designed to support aft fuselage assemblies for rework or storage. It is adaptable for use on an aircraft carrier or at a shore installation.

The rail size, adjustment features, and rail couplings permit the stand to be used in conjunction with existing engine adapters and positioning trailers. The rail couplings are also designed so that a series of workstands may be joined for additional length.

The rail length is 152 inches. Rail widths are adjustable to either 30 or 48 inches between centerlines. Height adjustment is infinite between 28 1/2 and 40 1/2 inches.

The stand may be tied down with four 5/8-inch diameter bolts at each of 6 legs (total of 24 bolts). The rated capacity of the stand is 10,000 pounds. Stop latches prevent overriding; latches are spring held in stop position and must be held down manually to allow entrance or exit or engine adapters used in conjunction with rail type stands.

TESTING CONSOLE

Some engines require special testing consoles. The console provides the electrical circuits (not normally found in a test cell) needed to satisfactorily conduct functional and performance tests.

The consoles provide junction facilities to connect the cell power to the engine; a system for remote control and measurement of throttle

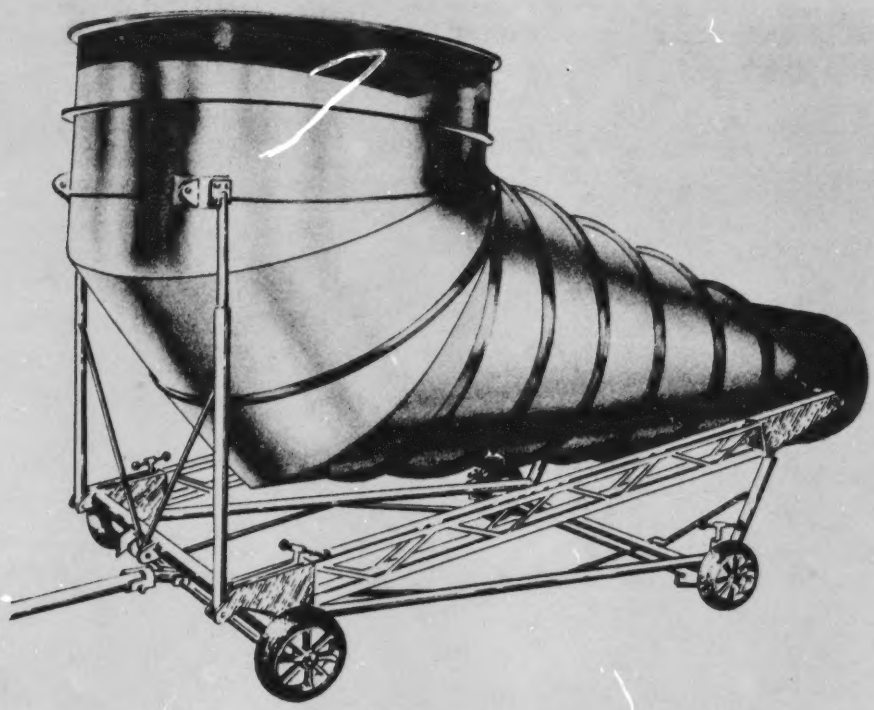

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Figure 8-16.—Portable turbojet engine exhaust sound suppressor.

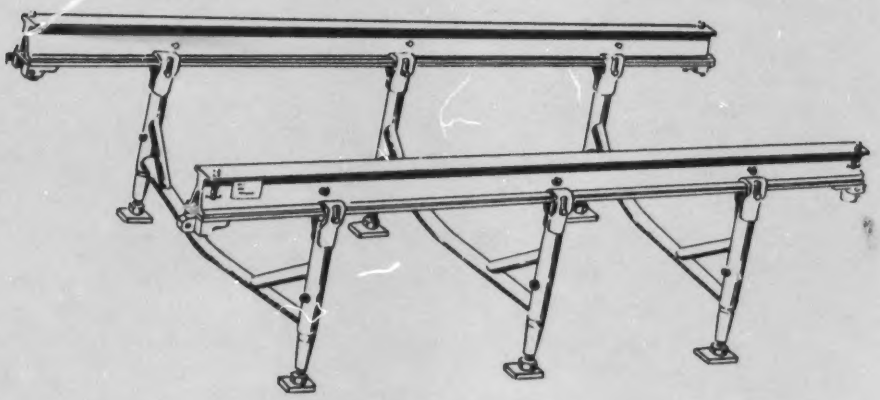

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Figure 8-17.—Model 3110 workstand.

position; a selsyn transmitter and receiver to indicate inlet guide vane position, and a d-c electronic indicating system for the purpose of measuring nozzle position. Also included is a thermocouple type anti-icing temperature indicator, starter circuit, and switches and cables necessary for operation of the engine and console under test conditions.

CHAPTER 9

TURBOSHAFT-POWERED HELICOPTER MAINTENANCE

Two of the turboshaft-powered helicopters used by the Navy are the SH-3A and the UH-2A/UH-2B. This chapter covers the SH-3A as a typical helicopter for engine removal and installation, rigging and adjusting power controls, and testing the engine after installation. The SH-3A is also used as a typical helicopter for removal and installation of various components of the transmission system.

The only maintenance of the UH-2A helicopter covered in this chapter is the removal and installation of the powerplant.

Troubleshooting of the helicopter engine and transmission components is accomplished through the use of troubleshooting charts, provided in the appropriate MIM's, and the logical or deductive reasoning procedures outlined in chapter 6 of this manual.

SH-3A HELICOPTER

Navy helicopter, model SH-3A, is a twin engine, antisubmarine warfare (ASW) helicopter, designed for land and carrier-based operations. It is also capable of water landing and takeoff.

SH-3A features include a hull shaped fuselage and outrigger sponsons into which the main landing gear retracts. A fixed horizontal stabilizer is installed on the upper right side of the pylon and two T58-GE-8B gas turbine engines are mounted side by side above the fuselage forward of the rotary wing head.

Flight configuration is a five-blade main lifting rotary wing head and a five-blade rotary rudder. Forward, aft, lateral, and vertical flight are accomplished through the rotary wing head, while the rotary rudder counteracts torque from the rotary wing head and provides directional control.

Power to drive the rotary wing head is supplied through the main gearbox. The rotary rudder is driven through shafting which extends aft from the main gearbox, through the disconnect coupling and intermediate gearbox, and terminates at the tail gearbox. The main gearbox also incorporates a rotor lockout system which permits use of No. 1 engine to operate the generators and hydraulic pumps for ground handling purposes.

Three separate hydraulic systems are used in the SH-3A. The primary and auxiliary hydraulic systems are used in conjunction with the mechanical linkage of the flight controls. The auxiliary hydraulic system is also used in conjunction with the automatic stabilization equipment (ASE). The primary hydraulic system provides power for the retractable main landing gear, automatic blade fold system, windshield wiper system, and rescue and sonar hoist systems. It also supplies fluid to the rotor brake system.

POWERPLANTS

The two T58-GE-8B turboshaft engines (fig. 9-1), installed in the upper fuselage, are individually supported by a forward inboard mount, outboard strut, and aft support. Each engine is installed with the starter pointing directly forward and the tailpipe, secured to the power turbine casing, pointing away from the fuselage. Each engine consists of a gas generator and a power turbine. The gas generator consists of a front frame (which mounts the starter and engine accessories), compressor section, combustion section, and gas generator turbines. The power turbine includes the power turbines, power turbine shaft, and an exhaust casing. In addition, the engine incorporates an anti-ice system, fuel purifier, and two igniter plugs. The power turbine is preassembled to exhaust either to the right or the left.

Each engine is handled as a demountable powerplant for removal or installation. Each

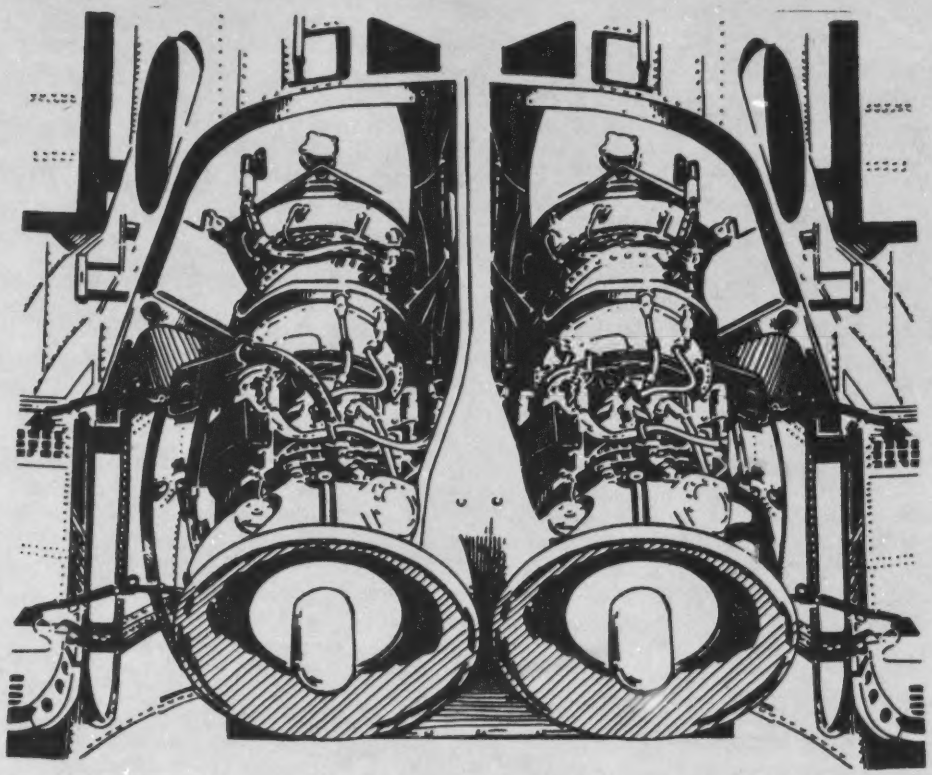

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Figure 9-1.—T58-GE-8B turboshaft engines installed (top view).

demountable powerplant consists of an engine, inboard mount, outboard strut, main drive shaft, tailpipe, fire seal, support, power turbine tachometer-generator, duct, and lubrication system. Also included in the powerplant are portions of the engine control, fuel, ignition, starter, and engine instrument systems. Disconnect points in each system are provided for rapid removal of the powerplant from the fuselage. Access provisions include hinged engine service platforms, removable engine aft cowlings, and a walkway across the upper fuselage. A removable panel in the firewall provides access to the fuel control and No. 2 powerplant.

Removal

To remove the engine, turn off all electrical power, hinge down the engine and transmission service platforms, and remove the engine aft cowling. Prior to disconnecting the fuel or oil lines in the engine compartment, a container must be provided and placed under the appropriate side of the helicopter at the engine compartment drain port. The oil tank may be drained by depressing the plunger on the drain valve in the engine compartment. Accumulated water may be drained from the centrifugal fuel filter by actuating the spring-loaded handle on the drain valve in the engine compartment. Disconnect the various drain lines, electrical leads, engine control rods, and duct assemblies in accordance with the technical instructions for the SH-3A helicopter. Place protective coverings on all fittings and electrical receptacles.

Separate the lower pole from the upper pole of the engine hoist assembly. Carefully lower

the plugged end of the lower pole through the hole in the engine service platform and insert it in the wing receptacle. Connect the upper pole to the lower pole.

Suspend the spreader bar assembly from the lifting hook of the hoist. Connect the forward auxiliary engine maintenance stand support to the mounting pad at the front frame section. To prevent damage to the rotary wing blades, position the blades to give maximum clearance when removing the demountable powerplant, and engage the rotor brake. Insert the aft section of the spreader bar in the hole in the rear engine support. Install the locking pin in the engine receiver at the front frame.

Adjust the position of the lifting ring on the spreader bar to insure proper horizontal angle of the demountable powerplant during removal and installation. Take up slack in the hoist cable and spreader bar with a slight forward lift on the engine. Remove the bolts, washers, and nuts securing the upper end of the outboard strut and hinge the strut toward the platform. Then remove the bolt, washers, and nut securing the forward inboard mount to the airframe. Unbolt and disconnect main drive shaft flange from main gearbox input flange. Unbolt and disconnect support from gimbal ring on main gearbox input. Check and keep bolts and nuts in matched pairs, since they will be reinstalled in the same position, in the same shaft from which they were removed.

After checking to make sure all hose lines and wiring have been disconnected and all clamps have been removed, lift the engine clear of the engine compartment. Swing the hoist and powerplant outboard and carefully lower the powerplant into the engine maintenance stand. Guidelines should be used while lowering the engine to keep it clear of the helicopter. Aline and secure the powerplant to the stand before removing the hoist. Figure 9-2 shows the SH-3A helicopter with the hoist and adapters used to lower the powerplant.

Installation

For installation of the powerplant, place the engine maintenance stand with the demountable powerplant installed forward of the sponson and with the forward section of the powerplant facing aft. Turn off all electrical power and remove the protective coverings from all fittings and electrical receptacles in the upper fuselage. Secure the adjustable end of the outboard strut to the fuselage with the bolt, washer, and nut. Connect the electrical wiring bundles to the four receptacles and lockwire the plugs. Install clamps to secure the wiring to the airframe. Position the wiring to eliminate interference when installing the powerplant.

Install the hoist and spreader bar as for removal. Remove the rear support cables and forward support pins and lift the powerplant clear of the stand. Carefully lift the powerplant to the approximate level of its installed position in the upper fuselage. Insert bushings from inside through holes in the yoke of the support. Lower the powerplant into the engine compartment with the rear of the powerplant slightly lower than the front. At the same time, slide the support through the opening in the canted firewall.

If installing No. 2 powerplant, while it is being lowered into the forward engine mount connect the electrical wiring to the oil temperature bulb. Safety wire the plug and clamp the wires. Check alinement of the main drive shaft flange with the main gearbox input flange. Aline holes in yoke of the support with holes in the gimbal ring on the main gearbox housing and install the bolts and tighten fingertight.

Carefully lower the powerplant into the forward bulkhead mount and secure the inboard engine mount to the bulkhead mount in the following manner. Insert the bolt with a thin washer under the head through the hole in the bulkhead mount. Position three thick washers and one thin washer on the bolt and install nut. Do not tighten nut at this time. To prevent damage to the engine check that two bushings are installed in the bulkhead mount prior to installation of the bolts, washers, and nut.

Connect the drive shaft flange to the main gearbox flange, using matched-marked sets of bolts and nuts and tighten to the proper torque. When it becomes necessary to replace a nut, all four nuts must be individually weighed to insure proper balance. Weight spread of the nuts must not exceed 0.035 grams.

To prevent damage to the powerplant, four special square-head bolts and nuts attaching the input drive shaft to the main gearbox flange must be retained and installed as matched sets. Bolts may be reinstalled, provided proper matchmarks can be ascertained. If matchmarks are not clearly defined, the drive shaft must be balanced. Tighten all nuts to the proper torque and then tighten the bolts on the support assembly and the inboard front engine mount.

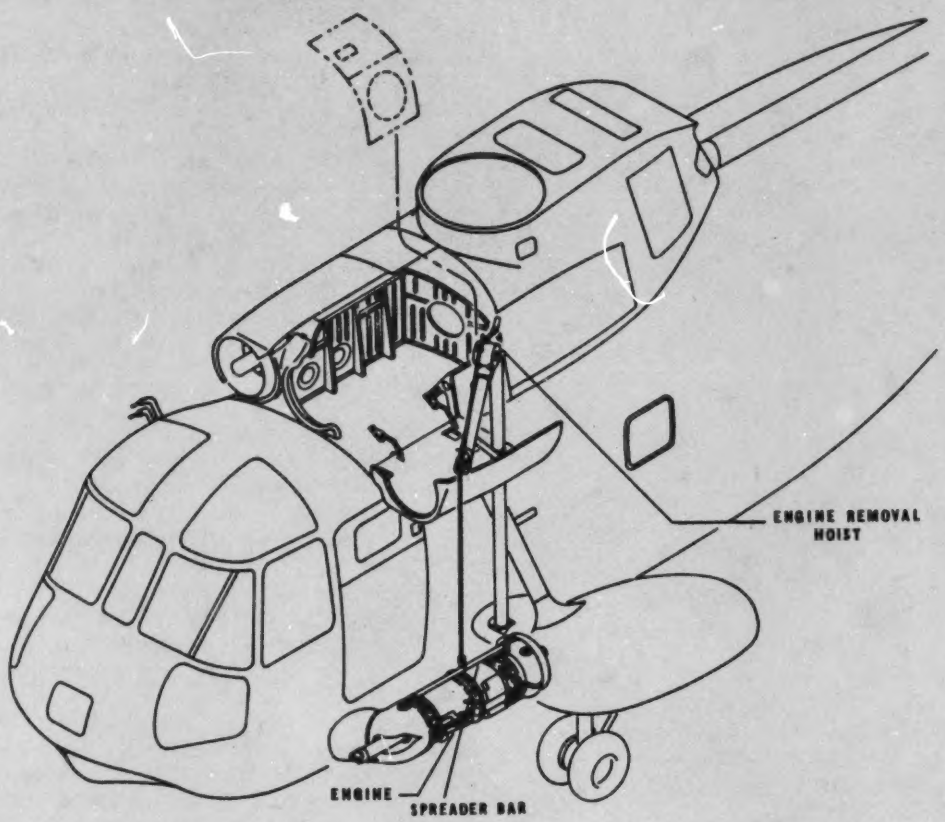

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Figure 9-2.—Hoisting engine.

To prevent fire in the engine compartment, check that the tailpipe extends beyond the skin line, when the powerplant is installed. If necessary, readjust tailpipe to extend beyond the skin line. After performing maintenance, and before leaving the engine platform, clean the step pads and area in front of the engines to prevent engine dirt ingestion.

Visually inspect the entire powerplant for completeness and accuracy of the installation, and account for all tools and spare parts.

RIGGING AND ADJUSTING

The rigging of the power controls is usually accomplished at the factory and no rigging is required except when some component has been changed. Rigging of power controls and emergency throttle controls is discussed in the following paragraphs.

Power Controls (SH-3A)

To rig the power control, first check the control cables for proper tension. If they are not at the proper tension, adjust them by turning the turnbuckle barrels. Be sure to turn each turnbuckle barrel the same number of turns during the tension adjustment. It is essential that all turnbuckle terminals be threaded into the barrel so that not more than three threads are exposed.

After adjusting the cables, hinge down the engine service platforms and set the centerline

of the push rod actuating lever up 29° from a line parallel with the top of the support assembly. Move the engine fuel control lever up against the closed stop, and check the length of the rod assembly. It should be 7 1/32 inches between the bearing centers for the No. 1 engine and 3 29/32 inches for the No. 2 engine.

Keep the engine fuel control lever at the fully closed position and adjust the forward stop, extending out of the forward support, until contact is made with the upper flat surface of the sector pulley. Now place the engine fuel control lever in the fully open position and adjust the aft stop until contact is made with the upper flat surface of the sector pulley. When the engine fuel control lever is placed in the shutoff position, the closed stop in the fuel control should contact simultaneously with the closed stop in the support assembly.

When the quadrant lever is placed in the closed position, there should be a 1/16-inch gap at the quadrant fixed stop. If not, adjust the cable length to correct this measurement and recheck the cable tension. Now move the quadrant lever to the 100 percent speed position and adjust the stop bolt on the quadrant assembly for a 1/16-inch clearance. This clearance must be measured on the outside diameter of the quadrant body. This should have the control lever adjusted, but to make sure, move the lever from open to closed position. Using a piece of paper, insure that the splined fuel control lever hits both the open and closed stops.

For minor adjustments the fuel control lever has an adjustment screw slot which may be used to insure bottoming of the fuel control stops.

Fuel control adjustments can be accomplished for fuel density, gas generator top speed, gas generator idle speed, and power turbine maximum speed. Gas generator top speed adjustments are made with a remote control, on the cabin ceiling. Fuel density, gas generator idle speed, and power turbine maximum speed adjustments are made from the engine service platforms.

Emergency Throttle Controls (SH-3A)

Hinge down the engine service platform. Disconnect the cable from the forked end of the emergency throttle fuel control lever. Turn the forked end to the midposition. Actuate the control lever on the fuel control and check the travel. (Travel of the control lever must measure a minimum of 0.997 inch.) Loosen and back off the open stop bolt in the cockpit, and actuate the cockpit emergency throttle control lever to check the teleflex system for ratcheting and binding. Pull and hold the emergency throttle control lever on the fuel control to full travel or open position and connect the cable to the forked end of the control lever.

In the cockpit, remove the emergency throttle control lever and reposition it on the splined shaft as close to the open stop bolt as possible. Set the emergency throttle control lever in the full open position, and reposition and secure the open stop bolt to allow 1/32- to 1/4-inch cushion effect between the lever and the open stop bolt. Close the emergency throttle with the cockpit emergency throttle control lever and check for 1/32- to 1/4-inch cushion effect between the lever and stop. If necessary, to obtain proper adjustment, reverse the open stop bolt and use the head of the bolt as the stop.

If desired results cannot be obtained by adjusting the throttle control levers, disconnect the cable forked end for fine adjustments. When the desired adjustments are obtained, reconnect the cable forked end. Check the emergency control linkage stroke at the fuel control lever by actuating the emergency control levers in the cockpit. Full travel must measure 1.297 inches maximum or have reached the main stop position on the fuel control, whichever occurs first.

After adjusting the controls and before hinging up the platform, insure that all the platform area is clean. Also clean the step pads in front of the engine to prevent dirt ingesting.

TESTING OF ENGINE INSTALLATION

Optimum engine performance is obtained by controlling gas generator speed (Ng) and power turbine inlet temperature (T5). This is accomplished by adjusting the engine fuel control to limit gas generator top speed. During adjusting procedures, the gas generator tachometer, turbine inlet temperature, and torquemeters must be monitored to prevent overspeed, overtemperature, or overtorquing of components. Fuel control adjustments are made with the remote control located on the cabin ceiling aft of the personnel door.

Prior to starting the adjustment procedures, arrange for an interphone connection between the pilot and maintenance man even though it is possible for him to see the instruments. In addition, a torquemeter reading of 112 percent must not be exceeded.

With a qualified pilot at the controls and the unaffected engine in GND IDLE, advance the affected engine speed selector lever for maximum power turbine speed (Nf). Gradually increase load, observing that gas generator speed (Ng) is increasing and Nf is decreasing. Continue increasing the load, until Ng no longer increases. At this point observe Nf and continue increasing load until Nf has decreased an additional 1 to 2 percent (200 to 400 rpm).

To establish the exact point at which the gas generator top speed is set, it is permissible to perform a topping check by operating the affected engine with T5 above 677° C for a period not to exceed 15 seconds. Under no circumstances, however, should the engine be operated with T5 above 687° C. If T5 is more than max temperature, reduce the load and rotate the remote control counterclockwise. Increase the load, recheck, and readjust if necessary until T5 is within limits. If T5 is less than 677° C and Ng is less than 100 percent, reduce the load and rotate the remote control clockwise. Increase load, recheck, and adjust if necessary. After adjusting the gas generator top speed, the idle speed can be set. Set the engine speed control lever to the GND IDLE position, and observe the tachometer. If the engine does not idle at 56± 3 percent, record the reading, stop the engines, and turn the fuel control idle adjustment until the desired reading is achieved. One full turn of the adjusting screw changes the idle speed approximately 3 percent. To set the power turbine maximum speed, advance the speed selector for maximum power turbine speed (Nf) approximately 108 percent. If the turbine speed is low and the indexing plate is not against the adjusting screw, the engine controls must be rerigged. If the indexing plate is against the stop, adjust the stop as necessary. One and one-half turns change Nf approximately 1 percent.

The engine is usually set to operate on JP-4 fuel, but may be set for operation on JP-5. To set the fuel control for JP-5, turn the fuel density adjustment plug counterclockwise until the line on the fuel control casting is in line with the JP-5 line on the index plate. Secure the fuel density adjustment plug with the retaining ring and lockwire. It may be necessary to lift the No. 2 engine to reach the fuel density adjustment.

TRANSMISSION SYSTEM (SH-3A)

The transmission system consists of the main gearbox, tail drive shaft, oil cooler and blower, and the pylon transmission installation, which includes the intermediate and tail gearboxes. The main gearbox drives the rotary wing head, tail drive shaft, and accessory components. The accessory components, including the main gearbox, oil pumps, generators, and hydraulic pumps, are driven whenever the left engine or both engines are operating. The rotor lockout system prevents the rotary wing head and rotary rudder from turning during ground runup.

The component location of the transmission system is shown in figure 9-3. This section covers the removal, installation, and trouble-shooting of the various components of the transmission system.

MAIN DRIVE SHAFT

The main drive shaft is a dynamically balanced shaft that transmits torque from the engine to the main gearbox. It consists of a high speed shaft, Thomas coupling, engine adapter, match-marked nuts for engine attachment, and match-marked bolts and nuts for attachment to the main gearbox coupling. The Thomas coupling and engine adapter are secured to the shaft by special bolts and hi-lok collars to prevent disassembly. The shaft is made of tubular steel, approximately 13 1/2 inches long. It is flanged at both ends for connection to the Thomas coupling, adapter, and power turbine cooling flange, and to the main gearbox coupling flange. The drive shaft is housed within and protected by the aft engine support. Direction of rotation is clockwise when viewed from the aft end of the engine. To remove the main drive shafts both demountable powerplants must be removed.

Removal

With the powerplant removed and the support assembly removed, the main drive shaft can be removed by removing the bolts and nuts from the flexible steel disc. When removing the flexible steel disc, the laminations must be maintained in the original sequences and relative position. The laminations are matched and should be tightly secured together with lockwire before removal. Remove the flexible steel disc,

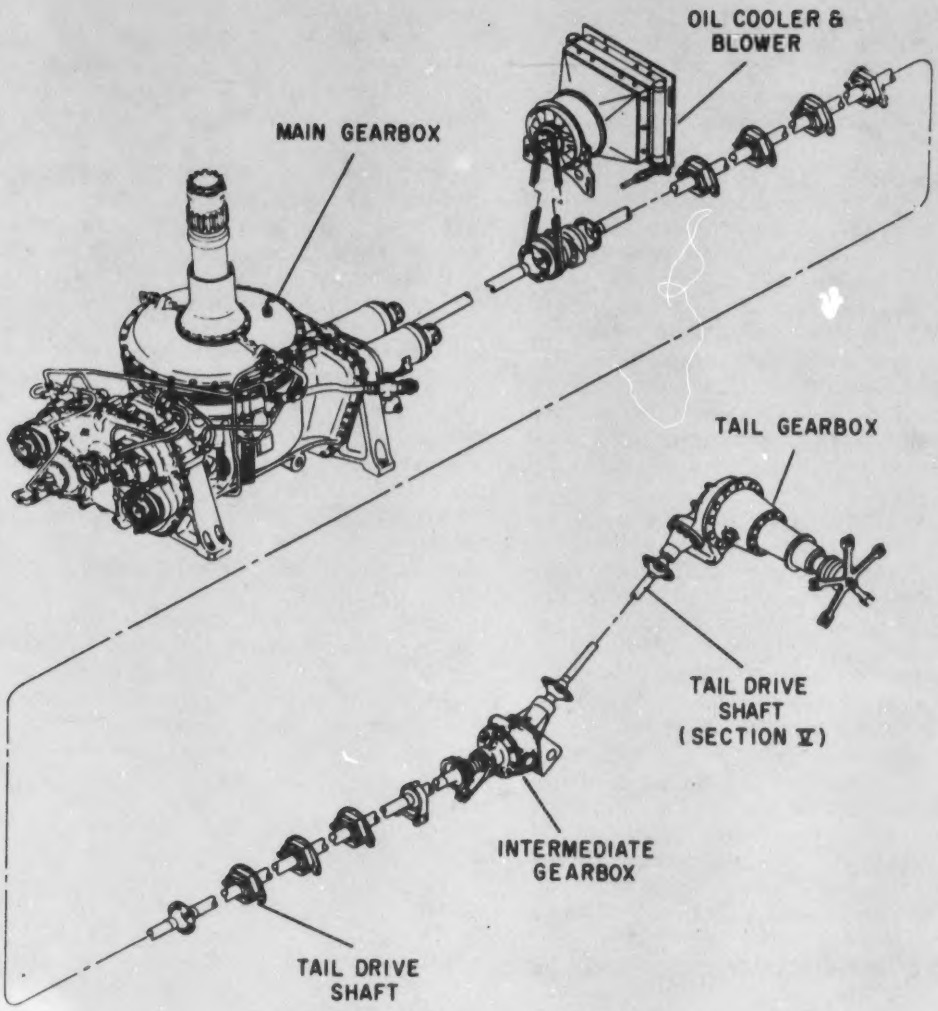

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Figure 9-3.—SH-3A transmission system (component location).

conical washers, and adapter from the polygon coupling flange by removing the nuts and bolts.

Installation

Installation of the main drive shaft is accomplished by positioning the adapter against the polygon coupling flange and aligning the three holes in the adapter with the three holes in the polygon coupling flange. Position the flexible steel disc so as to align the three holes with the adapter. Insert a conical washer on each side of the flexible steel disc and secure the flexible steel disc and adapter to the polygon coupling flange with the bolts and nuts. Tighten the nuts to the proper torque. Align the three holes in the

triangular flange of the main drive shaft with the three holes in the flexible steel disc. Insert a conical washer on either side of the flexible steel disc and secure the drive shaft to the flexible steel disc with the bolts and nuts. Tighten the nuts to the required torque. Install the supported assembly; the engine is then ready for installation.

MAIN GEARBOX

The main gearbox is located on the transmission deck aft of the engines. It drives the accessories, supports and drives the rotary wing head, and provides the power takeoff to drive the rotary rudder. The accessories, which include two generators, two transmission oil pumps, three hydraulic pumps, and a rotor tachometer-generator, are driven through freewheel units. When the rotary wing head is disengaged, the accessories are driven by a through shaft geared to the No. 1 engine.

Torque sensors, incorporated in the input section, sense engine input torque indications which are transmitted to the engine torque indicators, mounted on the instrument panels. Lubrication of the main gearbox is accomplished by a self-priming wet sump system. The No. 1 oil pump is mounted on the lower left side of the rear cover and supplies oil to the oil cooler and lubricating jets. The No. 2 oil pump is mounted on the upper right side of the rear cover. Each oil pump acts as a backup for the other oil pump in case of failure. Oil lines from the two pumps are connected by a tee, from which the oil is routed to the oil cooler and lubricating jets. An oil level sight gage is located on the lower left side of the main gearbox housing. The oil filler tube is located above the sight gage. A transmitter sends oil pressure readings to the transmission oil pressure gage mounted on the instrument panel. A temperature bulb located in the strainer in the lower housing transmits oil temperature readings to the oil temperature indicator mounted on the instrument panel. A chip detector plug in the bottom of the lower housing permits inspection of the main gearbox for metal chips. The chip detector plug is also connected in series with the intermediate and tail gearbox plugs to a warning light in the cockpit.

Removal

For removal and installation, the main gearbox is handled as a quick change unit, either by itself or with the rotary head installed. Accessory components are removed, if necessary, after the main gearbox has been removed from the helicopter. To facilitate removal of the linear actuator, place the accessory drive switch in the flight position before removal of the main gearbox. Hinge down the engine and transmission service platforms and remove the engine aft cowling and the rotary wing fairing halves. After opening all access doors, remove the access panel from the aft rotary wing fairing. Turn of all electrical power, disconnect the electrical plug at the chip detector, and install the drain fitting. Drain the oil in a suitable container.

After draining the oil, replace the chip detector. For the step-by-step procedure for disconnecting the main gearbox, the operation and service instructions manual should be followed. When all the lines and connections are disconnected, install the engine supports. Disconnect the input flange from each engine main drive shaft flange. After disconnecting the engine aft supports from the gimbal rings, remove the first section of the tail drive shaft with the flexible steel couplings. To prevent damage to the main gearbox, accessory components, or helicopter during removal of the main gearbox, check to insure that all electrical and lubrication lines have been disconnected. Using a sling and a suitable hoist with a rated capacity of 3,500 pounds, remove the main gearbox and lower it onto a cart.

Installation

For installation, the reverse procedures are used, When the installation is complete, service the hydraulic tanks and check for leaks. Tighten all lubrication line connections and fittings and service the main gearbox with lubricating oil. Install the engine aft cowlings, rotary wing fairing halves, and the access panel on the aft rotary wing fairing and check for security. After 5 flight hours, retorque the gearbox mounting bolts to the specified torque.

MAIN GEARBOX OIL COOLER AND BLOWER

The main gearbox oil cooler and blower unit of the SH-3A helicopter (fig. 9-3) is located in the aft rotary wing fairing. It consists of a cooler (radiator), blower, and duct. The cooler is belt driven by the tail drive shaft and forces air through the radiator. Hot oil from the main

gearbox sump is forced into the radiator. If the temperature of the oil is less than 70° C, the oil is bypassed to the return line by a thermostatic regulator. Oil returning from the radiator or the bypass is forced through the lubricating jets in the gearbox.

Removal

For removal of the oil cooler and blower, hinge down the transmission service platforms and remove the rotary wing fairing access panels. Drain the oil from the main gearbox and with all electric power off disconnect the wiring from the fire extinguisher bottles and remove the clips from the blower. Remove the belts from the driven pulley by lowering the oil cooler and blower. Do not remove the belts from the drive pulley on the tail drive shaft. Disconnect the hoses and remove the clamps. Separate the blower from the radiator and remove the blower, then remove the radiator.

Installation

For installation, position the radiator and support on the bulkhead with the bolts, but do not tighten the bolts. Attach the blower to the radiator and position the oil cooler and blower on the forward support. Install the bolts, but do not tighten. Install the oil hoses and clamps. Install the pulley belts on the driven pulley and the driving pulley on the tail drive shaft. Position the oil cooler and blower, using the special jack. Adjust and aline the pulley belts and tighten the holddown bolts. Connect the wiring for the fire extinguishers. Service the main gearbox with lubricating oil. If the oil cooler has been drained, an additional gallon of lubricating oil must be added to the gearbox. Install the rotary wing fairing access panels and hinge up the transmission service platforms.

ROTOR BRAKE

The rotor brake system permits applying the main rotor brake manually or automatically. It incorporates a master brake cylinder, pressure gage, panel package, rotor brake, rotor brake accumulator, check valves, and pressure switches. Operation of the system is closely associated with the operation of the automatic blade folding system.

The rotor brake, located on the input cover of the main gearbox, is hydraulically actuated to stop the rotation of the rotary wing head. Actuation is accomplished manually by means of the rotor brake master cylinder in the cockpit, or automatically during blade folding by the blade positioner control valve. In manual operation, the rotor brake is capable of stopping the rotary wing head in 14 seconds from 157 rpm. The rotor brake consists of a rotor brake disc and housings containing four pistons and four brake linings.

Removal

To remove the rotor brake, hinge down the engine transmission service platforms and remove the engine aft cowlings. Disconnect the hydraulic lines and remove the elbows, nuts, gaskets, and rings. Remove the rotor brake from the main gearbox by removing the washers and nuts; then the rotor brake disc can be removed by removing the six bolts that secure it to the drive.

Installation

After repairs and before installation of the rotor brake, check the thickness of the brake disc. It should not be less than 0.460 inch. If the thickness is within limits, you can proceed with the installation.

Loosen all four of the adjusting pin nuts and push the pistons as far into the brake housing as possible. Now position the rotor brake disc and shims on the input bevel gear flange and secure with the bolts. Before installing the brake assembly, check the runout of the disc. If it is within limits, install it on the main gearbox. Adjust the thickness of the shims to center the rotor brake disc in the brake housings to within 1/32 inch. With the rotor brake disc secured on the main gearbox, check the distance between the edge of the blade positioner drive unit gear and the edge of the rotor disc. If the dimension is not within limits, reshim the positioner drive unit. After obtaining the proper clearance, install the elbows, nuts, gaskets, and rings. Install the hydraulic lines and bleed the brake system to remove the air. Actuate rotor brake master cylinder several times and then check the clearance of all four brake lining pucks. Minimum allowable clearance between the puck and the rotor brake disc is 0.045 inch. If the proper clearance cannot be obtained, replace the rotor brake.

TAIL DRIVE SHAFT

The tail drive shaft extends from the tail takeoff coupling flange at the rear cover of the main gearbox to the disconnect jaw of the intermediate gearbox. The primary purpose of the shaft is to transmit engine power to drive the rotary rudder. It also provides the drive for the main gearbox oil cooler and blower fan. The tail drive shaft is composed of five sections. Section I consists of a shaft and two Thomas couplings. Section II consists of a flanged shaft, pulley, bearing support housing, and a flange. Section III consists of a shaft, four bearing supports, and two flexible steel couplings. Section IV consists of a shaft, four bearing supports, and a disconnect coupling jaw. Sections I and II are enclosed in the aft main rotor fairing. Section III is enclosed in the aft main rotor fairing and the tail drive shaft access fairings. Section IV is enclosed in the tail drive shaft access fairings. Section V is mounted in the pylon and consists of a shaft and two flexible steel couplings.

Removal

To remove the tail drive shafts, fold the pylon and remove the main rotor fairing screen, hinge down the transmission service platforms and open the tail drive access fairings. For the step-by-step procedures, the applicable technical instructions should be consulted. The following paragraphs give a brief removal procedure of the tail drive shafts.

To remove section IV, remove the bolts and nuts from the bearing rings and remove the rings. Remove the bolts on the right side of the bearing support plates. Remove the lower bolts on the left side of the bearing support and loosen the other. Swing the support plates up and out of the way. Do not remove the bearing support plates, because installation out of the original position results in tail drive shaft misalinement and excessive runout. The same procedures can be followed for the removal of the other shafts except section II. The oil cooler and blower drive belts must be removed from the driving pulley to remove section II.

Installation

For installation, the reverse procedure is used, but upon completion a runout of the shafts is required. Any excessive misalignment will cause vibrations and damage to the drive shafts. Refer to the applicable technical instructions for the correct procedures and limitations.

INTERMEDIATE GEARBOX

The intermediate gearbox (fig. 9-3) is located forward on the pylon where it joins the aft fuselage. The intermediate gearbox transmits torque and changes the angle of drive from the main gearbox to the tail gearbox. It consists basically of an input housing and gear assembly, with a spring-loaded disconnect jaw, a center housing, and an output housing and gear assembly. The spring-loaded disconnect jaw provides a means of folding and unfolding the pylon without manually disconnecting the transmission. When the pylon is folded, the pylon transmission components are locked to prevent the rotary wing from windmilling. When unfolded, the lock automatically disengages. The input and output housing contains similar bevel gears to change the angle of drive up along the pylon. The center housing incorporates an oil level sight gage on the left side, the magnetic drain plug on the bottom, and the filler plug at the top. The gearbox is splash lubricated and air cooled.

Removal

To remove the intermediate gearbox, drain the oil and remove the fairing from the pylon, and fold the pylon. Insure that all electrical power is off; then disconnect the electrical wiring at the pylon terminal block and chip detector plug. Remove the grommet and clamp securing the wiring and pull the wiring upward through the bracket. Support the tail drive shaft and disconnect it at the flange of the output housing. Support the intermediate gearbox, remove the bolts securing it to the bracket, and remove the gearbox. Unbolt and remove the bracket.

Installation

For installing the intermediate gearbox, install the bracket and install the gearbox after insuring that the correct shims are on the studs. Check the alignment of the gearbox and position the flexible steel coupling of the tail drive shaft on the output housing of the gearbox. Position the convex seat of each coupling washer against the coupling. Install the shims equally at each ear of the flange. Place the unused shims under the boltheads and washers. Secure this stackup to the output housing of the intermediate gearbox. Shims should be installed equally at each end of the drive shaft sections. Insert the electrical wiring through the bracket and connect it to the

chip detector and plyon terminal block. Install the grommet, secure the clamps, and safety wire the chip detector plug. Remove the support from the tail drive shaft and unfold the plyon. Service the gearbox with lubricating oil and replace all fairing.

TAIL GEARBOX

The tail gearbox (fig. 9-3), mounted at the top of the pylon, serves as the attachment for the rotary rudder, changes direction of the drive 90°, and reduces the shaft speed. An actuator shaft, controlled by the rotary rudder flight controls, operates the pitch control beam. The pitch control beam is connected to the sleeve of each rotary blade to change the pitch of the blades. The gearbox is splash lubricated. A magnetic drain plug is installed in the bottom of the input housing. Access to the tail gearbox is gained by removing the tail gearbox access fairing at the top of the pylon.

Removal

To remove the tail gearbox, first remove the rotary rudder, but leave the pitch control beam with the tail gearbox. Insure that all electrical power is off; disconnect the fairing and rotary beacon anticollision light. Disconnect the electrical wiring from the chip detector plug and drain the oil in a suitable container. Disconnect and remove the bellcrank and control rod. Support the upper end of the tail drive shaft and disconnect it at the input flange. Retain the nuts, bolts, and shims. Install the lifting eye on the tail gearbox. With tension on the hoist, remove the bolts, washers, barrel nuts, and shims securing the tail gearbox to the support. Now remove the bolts securing the tail gearbox, hoist the tail gearbox from the helicopter, and place in a stand. Retain all washers and shims for installation.

Installation

After repairs have been completed and the tail gearbox is ready for installation, lift the gearbox into position and align it in accordance with the applicable technical instructions. After alignment, install and secure the bolts, washers, barrel nuts, retainers, and shims to the support. Remove the lifting eye and torque the bolts to their proper torque. Connect the tail gearbox to the flexible steel coupling. Install the coupling shims equally at each ear. Connect the control rod to the bellcrank and secure it. Install all fairing removed and install the rotating beacon

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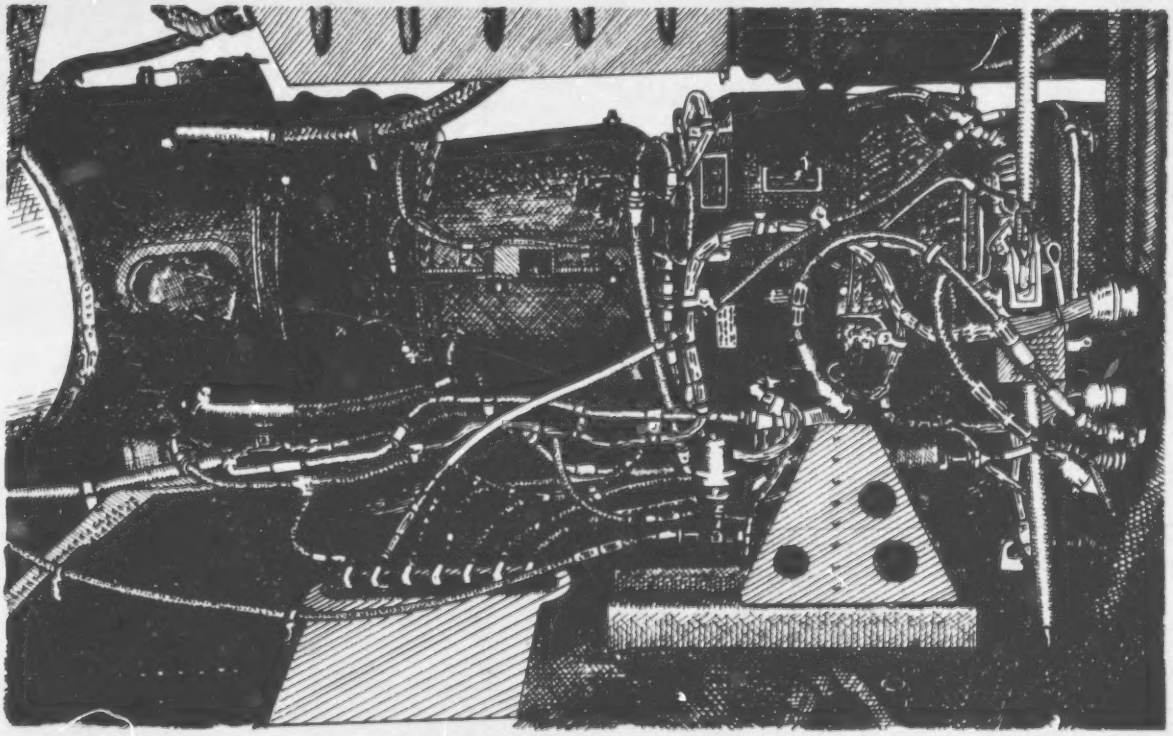
Figure 9-4.—UH-2A/UH-2B helicopter.

anticollison light. Insure that all electrical power is off; then connect the wiring to the anti-collision light and the magnetic chip detector. Install the rotary rudder fairing and service the gearbox with lubricating oil.

UH-2A/UH-2B HELICOPTERS

Navy helicopters, model UH-2A/UH-2B, are single turbine engine helicopters. The primary mission of the helicopter is plane guard for carrier operations. Alternate missions include personnel transfer, reconnaissance, and search and rescue operations. Power is supplied by a single T58-GE-8B gas-turbine engine located at the upper middle section of the fuselage. The engine is mounted with its speed decreaser gear aft, with the main drive shaft extending forward to the rpm reducing main gearbox, through which the main and tail rotor assemblies are driven. A one-way clutch unit is provided as part of the main gearbox to permit free-wheeling of the main rotor for autorotational flight. The main transmission also provides a pad on which the transmission oil system pump is mounted. The pump supplies pressure lubrication for the main and accessory gearboxes and provides the takeoff for the tail rotor drive shaft. An accessory gearbox, mounted forward of and driven through the main transmission, includes the pilot-operated rotor brake system and provisions for driving the No. 1 and No. 2 generators, the rotor tachometer-generator, the hydraulic pump, and the resolver gearbox.

Propulsion and lift are provided by the single four-bladed main rotor mounted on the main transmission rotor shaft. The directional control characteristics of the main rotor are supplemented by the three-bladed antitorque tail rotor which is mounted on the drive shaft of the



AD.258

Figure 9-5.—Powerplant for the UH-2A/UH-2B helicopter (right-side).

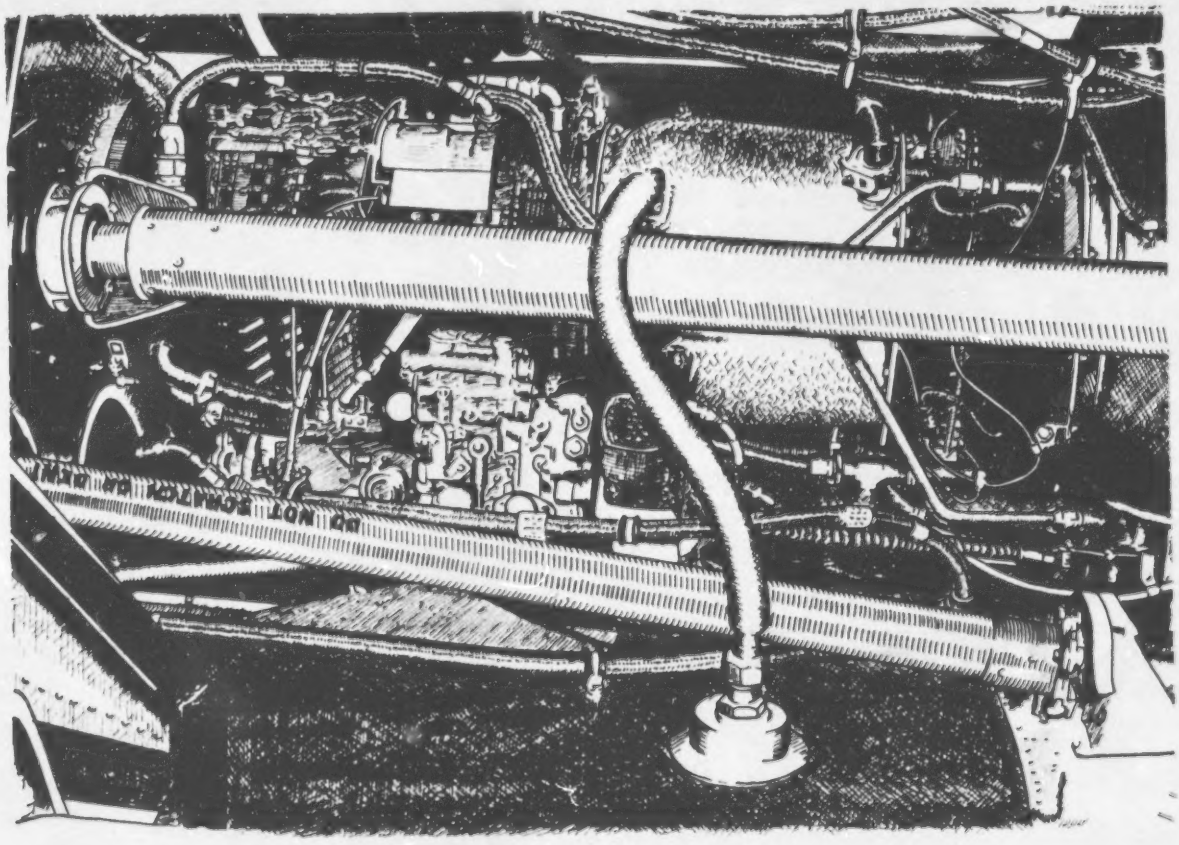
tail rotor gearbox located at the top of the tail rotor pylon.

Flight control is provided by direct mechanical linkage between the pilot-operated cyclic and collective sticks and the main rotor blade flaps, and between the directional control pedals and the tail rotor blades. These manual controls are supplemented by automatic stabilization equipment which is used, at the option of the pilot, to maintain a particular flight pattern.

The two main wheels of the three-point landing gear are retractable and are equipped with pilot-operated brakes having parking lock provisions. The tail member of the landing gear is a swivel type wheel equipped with a pilot-operated locking system for locking the wheel in a fore-and-aft position. The tail surfaces consist of a fixed vertical pylon structure which supports the tail rotor gearbox and tail rotor drive shaft and a fixed horizontal stabilizer.

The rescue hoist is stored in the forward section of the nacelle, and swings out and forward to a position where its operation can be observed by the pilot. Hydraulic power to the hoist motor and hoist boom is controlled electrically by two solenoid-operated control valves equipped with a manual override.

A cargo hook is attached to the underside of the fuselage just aft of the main landing gear. Controls are provided which permit either



AD.259

Figure 9-6.—Powerplant for the UH-?A/UH-2B helicopter (left side).

manual or electrical release of the cargo-hook load and for automatic release when the weight of the load is reduced by contact with the ground.

Figure 9-4 shows the UH-2A/UH-2B helicopter.

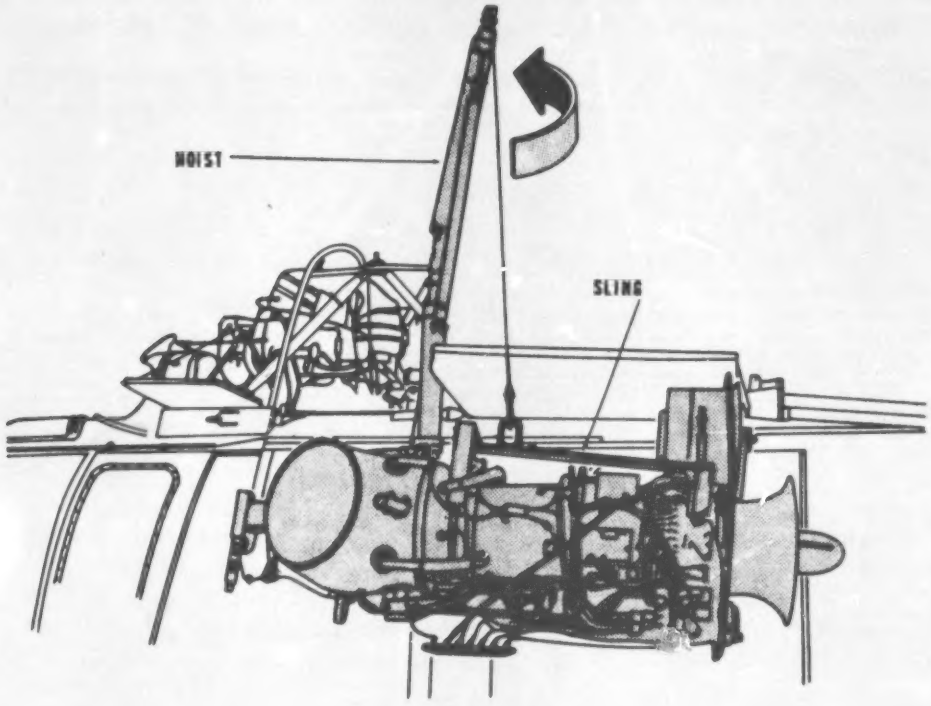
POWERPLANT

The UH-2A/UH-2B helicopters are powered by a single T-58-GE-8B turboshaft engine installed with the nose facing forward and supported by engine mounts which are bolted to the fuselage. Air is supplied to the engine through an inlet duct which is provided inside the right-hand side door of the center nacelle with an alternate air door attached to the duct by means of a hinge. Air is supplied through the alternate air door when an insufficient amount of air is supplied to the engine through the inlet screen because of icing and/or other contamination. The installation of the engine provides for ease of maintenance by allowing ready access to all accessories and components when the nacelle assembly is removed. The engine is installed in the helicopter as a power package and should be handled as a package for purposes of removal and installation.

The powerplant package installed in the UH-2A/UH-2B is identical to the one installed in the SH-3A except for a few differences in installation. This section covers only the removal and installation of the powerplant of the UH-2A/UH-2B helicopter.

Removal

Figures 9-5 and 9-6 show the right and left sides of the installed powerplant in the UH-2A/UH-2B helicopter. Open and hinge down the engine work platform and remove the necessary portion or portions of the nacelle. After disconnecting the powerplant in accordance with



AD.260

Figure 9-7.—Hoisting engine on UH-2A/UH-2B helicopter.

the applicable technical instructions, proceed as follows:

Attach the engine sling to the engine-mounted lifting adapters. If the rotor blades are installed and in a folded position, detach the left lower blade support from the fuselage, moving it outward and upward sufficiently to clear the hoist during engine removal.

If the blades are unfolded, insure rotors clear the hoists at all times. It may be necessary to move the blades back and forth while removing engine to avoid blade contact with the hoist. Apply the hoist and take up the slack. Take up the weight of the engine with the hoist. Lift the aft end of the engine upward and pull the engine back to free the fire seal from the front frame support. Hoist the engine high enough to safely clear the tail rotor shaft and aft mounting link assembly. By means of the hoist, move the engine aft and away from the fuselage, being careful not to let the engine come in contact with the adjacent structure. Lower the engine into the dolly and disconnect the hoist from the engine. Cover all openings. Cap or plug all hoses, and cover the mounting pads with protective shields. Figure 9-7 shows the engine on the hoist.

Installation

Installation is the reverse of the removal procedure. Care must be taken not to let the engine come in contact with the fuselage while hoisting.

Hoist the engine until it is directly over the engine supports. Lift the aft end of the engine, and slide the engine forward so that the firewall will butt up against the forward portion of the front frame support. Lower the engine onto the fuselage support mounts. Be sure that the flanged bushings are in place in the engine mount. Secure the engine mounts to the proper torque. Remove the sling assembly and hoist. Install all control rods, lines, clamps, and supports removed. Connect all electrical leads and secure the clamps to the fuselage. Install the main transmission drive shaft coupling forward of the firewall. Service the lubricating oil tank and prime the engine fuel system by connecting electrical power to the system, disconnecting the discharge line of the fuel control and attaching a temporary line to a container of at least a 2-gallon capacity. Operate the boost pump to prime the engine fuel system. With the RPM control in the idle position, the system is fully primed when the temporary discharge line

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Figure 9-8.—UH-2C helicopter.

shows a definite steady flow of clean fuel. After the system is fully primed, reconnect the discharge line of the fuel control.

Be certain all foreign matter, tools, and hardware are removed from the engine compartment prior to engine runup. Check the installation for security of clamps, supports, and all connections. Secure all work platforms and access doors.

UH-2C HELICOPTER

The powerplant and related systems of the UH-2C helicopter differ from the UH-2A, -2B in that the twin engine powerplant in the UH-2C replaces the single engine installation in the UH-2A, -2B. (See fig. 9-8.) This additional power increases the allowable gross weight and provides for higher altitude hover and, most important from a safety aspect, for single engine return-to-base capability.

Each engine has a speed decreaser gear and is serviced with its own engine and speed decreaser gear oil system, oil cooler system, and independent fuel lines. Each engine drives aft through its speed decreaser gearbox into a combining gearbox which unites the power from both engines and delivers it to the transmission. The combining gearbox, in turn, incorporates freewheeling units to declutch the output of a nonoperating engine. All accessories are mounted on this gearbox to eliminate the accessory gearbox and mount and, thus, to render the forward upper deck area more accessible.

CHAPTER 10

TURBOPROP POWERPLANTS/PROPELLERS

With the development of the turboprop powerplant and propeller came added responsibility for the ADJ. In addition to powerplant maintenance the ADJ must know the operating principles of the turboprop aircraft propellers and the procedures for disassembly and assembly of these propellers. He must also be able to troubleshoot and correct propeller system malfunctions and rig and adjust propeller control mechanisms.

The purpose of this chapter is to provide a generalized picture of the procedures for maintenance and troubleshooting of the turboprop powerplant, which consists of an axialflow gas turbine power unit, a connecting structure which includes the torquemeter drive, a reduction gear assembly, and the propeller. The T56-A-10W powerplant, 54H60-77 propeller, and associated equipment installed on the P-3A aircraft and the T56-A-8/8A powerplant, A6441 FN-248 propeller, and associated equipment installed on the E-2A aircraft are used as typical installations for discussion in this chapter.

POWERPLANTS

Each of the four T56-A-10W turboprop powerplants installed on the P-3A aircraft is handled as a demountable powerplant for removal and installation. Included in the demountable powerplant are the torquemeter drive, a reduction gear assembly, and two tie struts. The assembly can be removed from the aircraft with or without the propeller installed.

All powerplant assemblies are identical except for the engine-mounted accessories. The two inboard (No. 2 and No. 3) assemblies have engine mounted cabin compressors, compressor oil coolers, and related ducting. A-C generators are mounted on engine Nos. 2, 3, 4, and the APU.

Each of the two T56-A-8/8A turboprop powerplants installed on the F-2A aircraft consist of an axial-flow gas turbine power section, a torquemeter assembly, and a reduction gear assembly. The power section is attached to the reduction gear assembly by an interconnecting structure consisting of the torquemeter assembly and two tie struts. Each powerplant package is interchangeable between the left and right nacelles. (See fig. 10-1.)

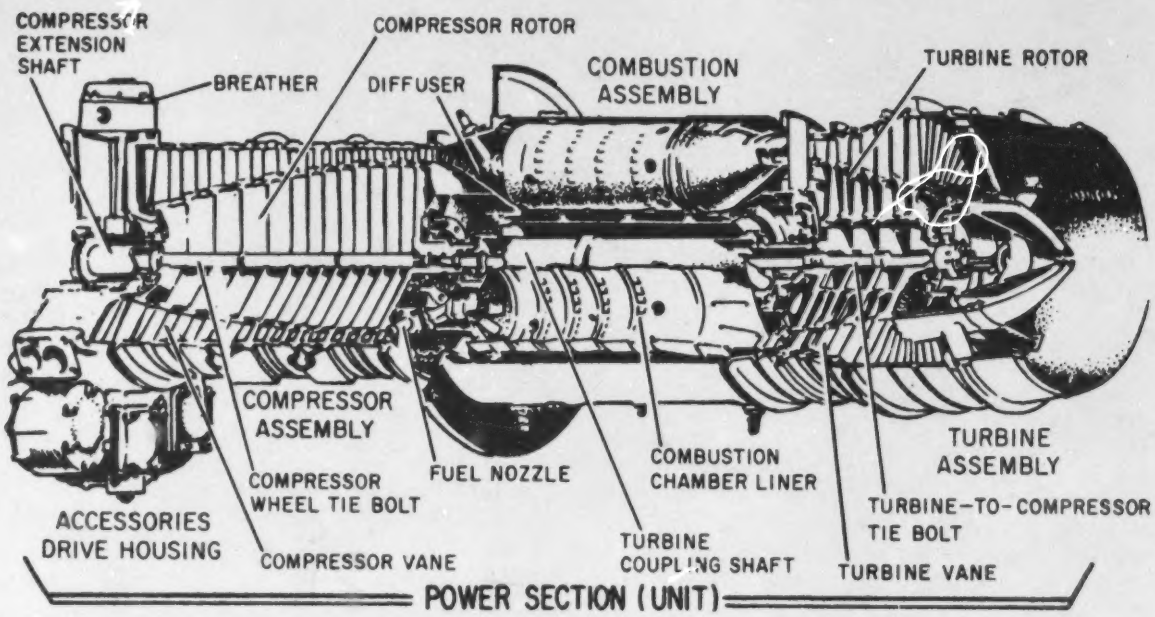
PRINCIPLES OF OPERATION

The T56-A-10W engine, during normal use, is performing four distinct operations—intake, compression, burning (which produces the power), and exhaust. In this respect, the engine is similar to a reciprocating engine, except that all four conditions are present all the time in the turbine engine.

The inlet portion consists of the engine air inlet duct and the engine guide vanes. The inlet duct is an aircraft part while the inlet guide vanes are the front end of the engine power section. The guide vanes direct the ducted air to the engine compressor. There are no rotating parts in the intake section.

After passing the inlet guide vane section of the engine the air enters a 14-stage rotating compressor section which increases the pressure by a ratio of 9.5 to 1. The last compressor stage discharges into an annular chamber called the diffuser section. The diffuser serves as a plenum or storage area of compressed air for use in the combustion liners.

The third phase of operation is the one which produces the power. In this section, commonly referred to as the "hot" section, the air enters six combustion liners where the fuel is injected through nozzles. The burning of the fuel increases the mass velocity and is delivered to the turbine section from the aft end of the



AD.175

Figure 10-1.—T56-A-8/8A powerplant assembly.

combustion liners. The high-velocity gases pass through four turbine stages which extract the energy created by burning the fuel/air mixture. The action of the gases turning the turbines is actually what generates the power. The turbine section generates a maximum of approximately 10,000 horsepower.

Turbine power is carried forward through a shaft to turn the compressor, which requires nearly 6,000 horsepower, and through a drive shaft from the compressor to the gearbox where the rpm is reduced and delivered to the propeller shaft. The reduction gear provides an rpm reduction from 100 percent engine, 13,820 rpm, to the propeller speed of 1,020 rpm. The reduction ratio is 13.54 to 1.

The exhaust phase takes place after the gases leave the last turbine stage. The turbine rear bearing support outer shell forms a nozzle to control the exhaust of the engine. A set of aircraft furnished swirl vanes is clamped to the rear end of the exhaust nozzle. The swirl vanes straighten the spinning motion of the exhaust as it leaves the last turbine stage and direct it into the bellmouth of the exhaust pipe.

The exhaust pipe is not directly connected to the engine but has an enlarged section at the forward end, the bellmouth, which surrounds the swirl vane and turbine nozzle section. The action of the engine exhaust gases passing into the bellmouth and tailpipe creates a venturi which, in turn, draws cool outside air through inlet openings around the hot section. This cooling-air flow reduces the temperature around the hot section and provides a boundary layer of cool air on the inside surface of the pipe.

A characteristic of the turboprop engine is that changes in power are not related to engine speed, but rather to turbine inlet temperature. During flight, the propeller, by its governing action, maintains a constant engine speed; this speed is known as the 100 percent rated speed and is the design speed at which the most power and overall efficiency can be obtained. Power changes are effected by changing the fuel flow. A change in fuel flow causes a change in turbine inlet temperature and a corresponding change in energy available to the turbine. The change in energy at the turbine results in a change of

torque available to the propeller, which then controls the blade angle as necessary to maintain 100 percent of design rpm.

REDUCTION GEAR

The reduction gear assembly incorporates a single propeller drive shaft, a negative torque signal system, a thrust sensitive signal system, a propeller brake, gearing to provide the necessary speed reduction, and an independent dry sump oil system.

The main reduction gear train consists of two stages of reduction. The spur gear first stage has a reduction ratio of 3.125 to 1. The self-aligning planetary type second stage has a reduction ratio of 4.33 to 1. This results in an overall reduction of 13.54 to 1. The reduction gear assembly also contains an accessory drive gear train which drives the accessories mounted on the reduction gear assembly. An engine starter, which operates through the accessory drive gear train, is also mounted on the rear case of the reduction gear. (See fig. 10-2.)

TORQUEMETER

It is essential to have a correct indication of the power developed by the engine. The engine operates at one speed, 100 percent rpm in all flight conditions from takeoff to landing, consequently rpm indication does not change with power changes. Also, engine power is directly related to ambient air pressure and temperature, velocity, and to a great extent, the cleanliness of the rotating parts.

The torquemeter assembly includes mechanical, structural, and electrical components. The torquemeter shaft assembly is composed of an inner shaft, or torque shaft, and an outer or reference shaft. A coupling connects the forward end of the engine compressor section to the aft end of the torque shaft.

At the time of assembly, both torque and reference shafts have a flange at their forward ends. These flanges then have slots milled, exactly in alinement, to provide 40 rectangular teeth on each shaft. When power is applied to the torque shaft, the shaft will twist, whereas the reference shaft, which receives no power, will not twist. This twisting action of the torque shaft results in misalinement of the two rows of exciter teeth in direct proportion to the power applied. Positive torque causes misalinement in one direction, and negative torque causes misalinement in the opposite direction. As the torquemeter turns, each tooth causes an electrical pulse in the pickup assembly. The pulses from the two sets of teeth are compared by a phase detector. The phase displacement is used, through a synchro transmitter, to actuate a synchro receiver in the horsepower indicator mounted in the cockpit. (See fig. 10-3.)

SAFETY COUPLING

The safety coupling is an automatic mechanical device which will decouple the power section from the reduction gear assembly when the negative torque exceeds the setting of the safety coupling. Positive torque occurs when the power section is driving the propeller through the reduction gear assembly. Negative torque occurs when the power section is being driven by the propeller.

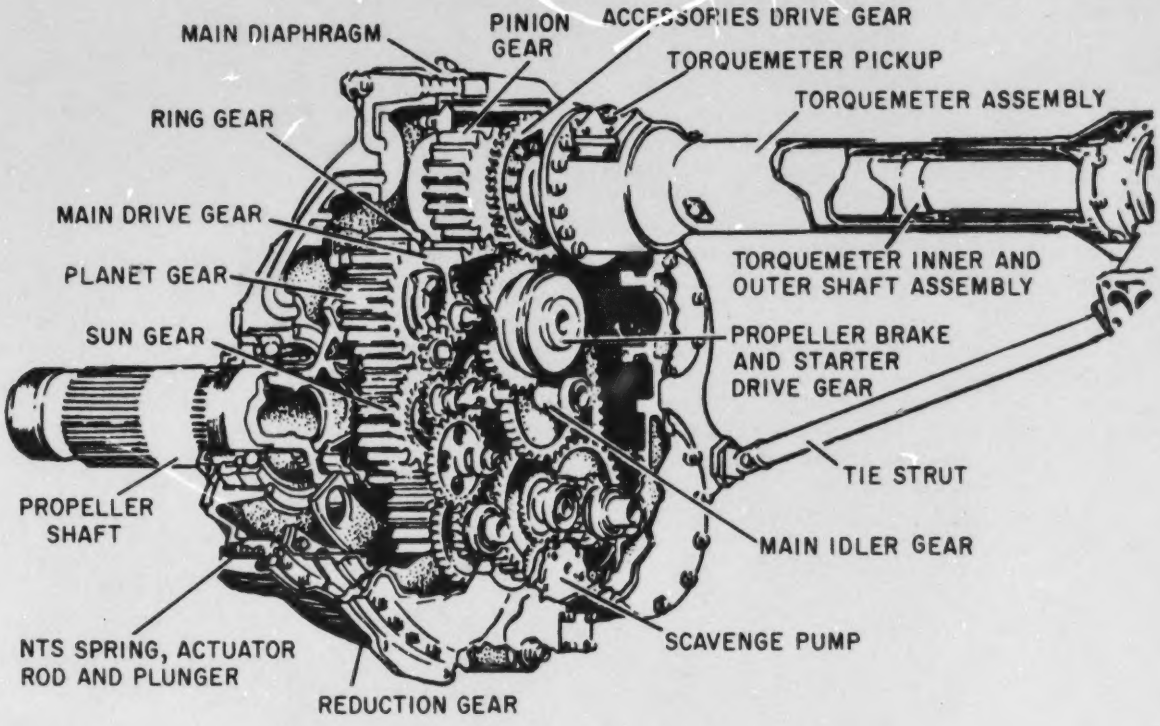
It takes approximately 10 times as much horsepower to drive a nonburning turboprop engine at its maximum rpm as it does to drive a nonburning reciprocating engine with a comparable horsepower rating at its maximum rpm. Therefore, if a turboprop engine were to have a power failure, and there were no safety devices, the propeller governor would attempt to maintain a constant engine speed by decreasing propeller pitch. As the pitch decreased, the blades would absorb more energy from the airflow across the blades to develop an ever increasing torque needed to maintain the constant rpm, but this torque is negative and the drag on the aircraft would be excessively high. It is for this reason that the propeller and engine must contain safety devices which limit the amount of negative torque that can be developed by the propeller. (See fig. 10-3.)

POWER SECTION

The power section assembly consists of a 14-stage axial-flow compressor assembly, 6 cylindrical through-flow combustion liners, a 4-stage turbine assembly, an accessory drive housing, and oil, fuel, ignition, control, and cooling air systems.

QUICK ENGINE CHANGE REMOVAL

The quick engine change (QEC) assembly consists of the powerplant, mounts, cowling, and fireseal. A crew of four is required to remove the QEC unit from the P-3A aircraft, two for disconnecting the QEC unit from the airframe and two to operate the hoist.



AD.177

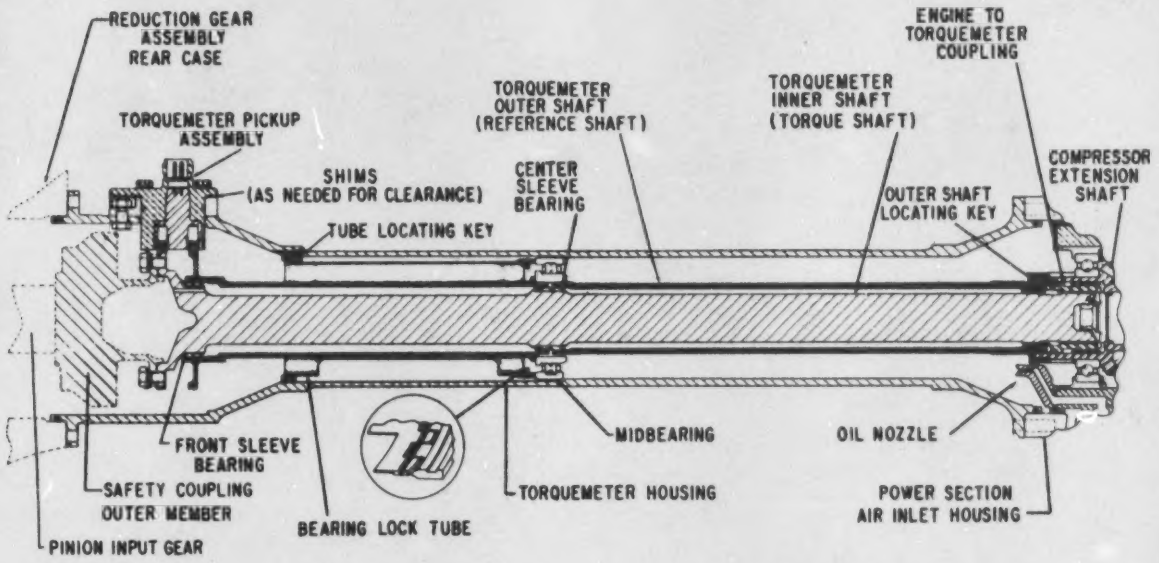
Figure 10-2.—Reduction gear and torquemeter assemblies.

CAUTION: Cap all lines as they are disconnected to prevent entrance of foreign material. With the aircraft resting on the landing gear or jacked at the shock struts, ballasting is required if more than one QEC is removed.

Before disconnecting any lines, make sure that all of the fuel valves are shut off and that all electrical power is removed. Open the engine side panels, remove upper and lower mount bolt access covers located on each side of the engine nacelle forward of the firewall. Remove the thermocouple access panel on top of the nacelle aft of the firewall and disconnect the thermocouple leads at the terminal board.

Remove the clamps securing bleed air duct at the right side of the firewall. Then disconnect the generator control, a-c generator power No. 1, No. 2 miscellaneous, a-c generator power No. 2, and No. 3 miscellanous connector plugs at the right side of the firewall. Disconnect the engine cyclonic breather at the right side of the firewall, also the fuel control drain line and the fuel manifold drip valve drain line. The temperature datum valve drain line can be disconnected at the temperature datum valve. Remove the wiring harness and other line retaining clips from the right side of the nacelle diagonal. Disconnect the fire detector line in two places near the top of the firewall.

On the left side of the engine firewall, disconnect the six wiring harness connectors, engine fuel feed line, water-alcohol feed line, wiring harness, and other retaining clips. (On inboard engines, disconnect the cabin compressor vent lines on the left side of the engine at the aft end of the bottom cowl panel.) Disconnect the labyrinth seal drain line at the nacelle diagonal. The coordinator electrical plug is disconnected at the coordinator, and the two control rods for the coordinator are



AD.176

Figure 10-3.—Torquemeter assembly.

disconnected at the power lever cable pulley and support rod at the pulley hub.

Release the 28 Camloc fasteners at the forward outer edge of the firewall. Remove the dust plugs from the QEC lift points (retain for reuse). Attach the engine sling at the lift points; using a suitable hoist, take up slack.

CAUTION: The QEC and engine sling must be adjusted to bring the hoisting eye over the center of gravity of the QEC. Failure to do so may result in engine damage.

NOTE: All the disconnects should be rechecked to make certain they are all disconnected before removing the mount bolts.

Remove the four mount bolts. The QEC is then ready to be removed. Move the engine straight forward out of the nacelle structure until the aft tailpipe is clear. Lower the QEC INTO POSITION ON THE QEC stand, and secure prior to removing the engine sling. (See fig. 10-4).

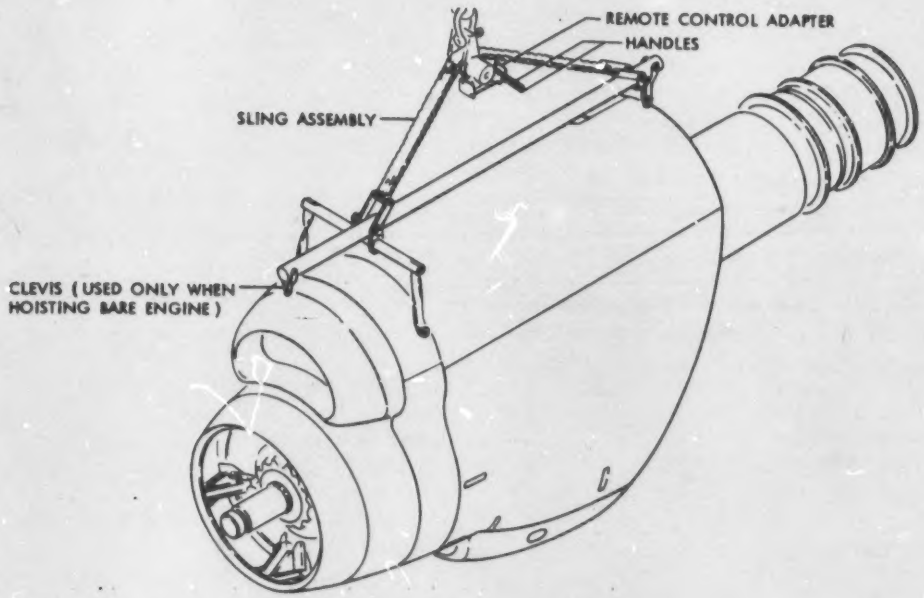
QUICK ENGINE CHANGE INSTALLATION

After the QEC has been built up and has been inspected, attach the engine sling to the lift points and lift the engine from the stand with an overhead hoist. The QEC must be balanced in the sling so that it will mate correctly with the nacelle structure when installed.

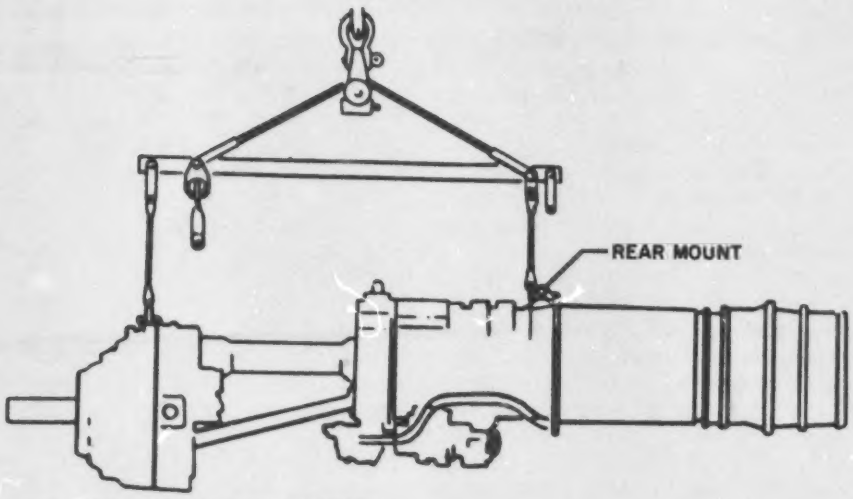
Apply a film of lubricant to the bronze rubbing surface of the aft tailpipe slides to prevent seizing. Move the QEC straight back into the nacelle structure and align the mount bolt-holes and the firewall. Start all four bolts before torquing. With all four bolts started, and using the correct torque wrench adapter, tighten the mount bolts to their proper torque. Remove the sling and install the dust plugs in lift point nuts. Using reverse procedure for removal, hook up the various lines and connectors. New O-ring seals should be used. The Maintenance Instructions Manual should be checked for the proper torque limits for the various camps and bolts.

ENGINE TESTING

After installation and any repairs to the turbine inlet or front case, turbine stator vane segment, or turbine rotor, an engine runup should be made. Before the actual runup is performed, a prestarting check should be completed. Statically check the following with special test



(A) HOISTING POWERPLANT PACKAGE



(B) HOISTING BARE ENGINE

AD.162

Figure 10-4.—Hoisting powerplant.

equipment: temperature datum valve, scheduling amplifier, and thermocouples. Adjust the emergency handle linkage to obtain full power, and check the power lever and engine coordinator positions at takeoff, flight idle, and max reverse. Measure and record propeller blade angle at the reverse and flight positions. With power lever at the 20° coordinator position, check operation by moving feather switch to feather position. The propeller blades should move toward the feather position. Immediately following this check, return the blade angle to the start position by holding the feather button in the unfeather position and the power lever at the 20° coordinator position. The propeller brake is operating if the propeller is hard to turn by hand. It should be impossible to turn the propeller in the reverse direction.

Prestarting Procedure

Before starting the engine, position the controls as follows:

1. Power level--start.
2. Emergency handle—normal.
3. Feather button—normal.
4. Water injection arming switch—off.
5. Rpm switch—low.
6. Engine start switch—to desired engine.
7. Temperature switch—to normal.
8. Autofeather and NTS check switch—normal.
9. Engine airscoop and inlet vane switch—off.
10. Fuel and ignition switch—off.
11. Start switch—pull out.
12. Primer switch—off.
13. Fuel governor and prop pitchlock switch—normal.
14. Pressure cutout override switch—normal.
15. Sync master switch—off.
16. Sync servo switch—normal.
17. Resync switch—normal.

Starting the Engine

To start the engine, turn the fuel and ignition on and hold the primer on until after light off. Then return it to the normal position. Depress the starter button; it should pop out at approximately 60 percent. If not, pull it out manually at 64 percent. During the start, the following action should occur:

1. The primary pump failure light should come on at 16 percent and go out at 65 percent.
2. The engine speed should stabilize at about 73 percent.
3. As the power lever is advanced above the 36° position, the low rpm switch should pop out and the engine speed should increase to 100 percent.
4. The 5th and 10th stage bleed valves should close at 94 percent, as evidenced by a decrease in the turbine inlet temperature.

The engine is now ready to make the test runs in accordance with applicable technical instructions.

PROPELLER

The turboprop propeller regulates engine torque to absorb engine power under varying conditions and converts the torque to thrust. Although the A6441 FN-248 (E-2A) propeller and the 54H60-77 (P-3A) propeller used in the following discussion are different, their functions are identical.

The model A6441 FN-248 propeller installed on the E-2A aircraft is a four-blade, hydraulically controlled, constant-speed propeller that has an integral hydraulic governing system. The propeller control system provides feathering and reversing, selective pitch control, negative-torque control, damping of hydraulic governor overcorrection, rpm syschronization, phase synchronization, anti-icing, and deicing. The main components of the A6441 FN-248 propeller are the hub assembly, the blade and retention assemblies, the regulator assembly, the feather reservoir, and the spinner assembly. (See fig. 10-5.)

The model 54H60-77 propeller installed on the P-3A aircraft has four blades, a diameter of 13.5 feet, an operating range of 101 degrees with a reverse angle setting of minus 13.25 to minus 15.45 degrees, low pitch stop setting of plus 13 degrees, and a feather angle of plus 86.65 degrees. The blade pitch changing mechanism in conjunction with the integral oil control assembly maintains a constant rpm of the engine at any condition above flight idle (alpha range). For ground idle and reverse (beta range) the propeller blades can be positioned to provide zero or negative thrust. Full feathering of the blades is provided to minimize drag of the propeller should engine shutdown be required in flight.

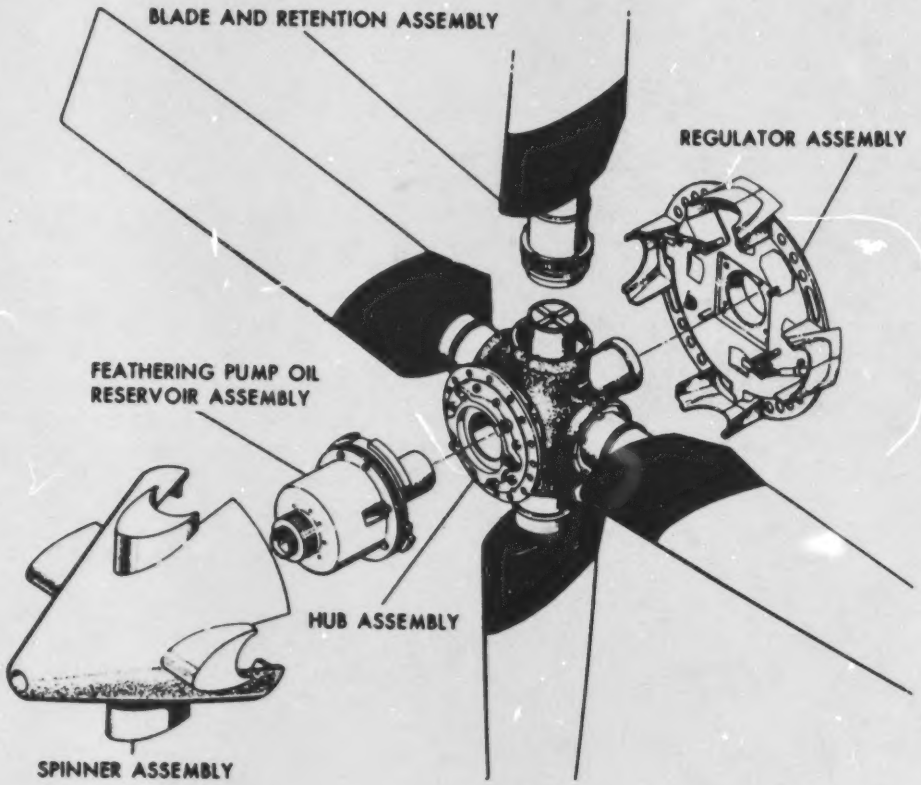


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Figure 10-5.—Propeller components (A6441 FN-248).

The main components of the 54H60-77 propeller are the barrel assembly, dome assembly, low pitch stop assembly, pitch lock regulator assembly, blade assembly, and the deicing contact ring holder assembly. (See fig. 10-6.)

OPERATING PRINCIPLES (A6441 FN-248)

The propeller acts as a governor of engine speed and is constantly acting against overspeed or underspeed conditions to maintain a constant engine speed of 100% rpm (13,820 rpm). If engine speed is high, the blade angle is increased. This causes a greater workload and slows down the engine. If engine speed is low, the blade angle is decreased. This reduces the workload and engine speed increases.

Propeller rotation drives four integral hydraulic pumps to supply the hydraulic pressure required for changing blade angles to compensate for blade loading, thereby maintaining a constant engine speed. Flow from the four pumps is directed through the negative torque signals (NTS) minimum pressure valve to the pressure control valve maintains system pressure at 450 psi above increase pitch pressure demand at any time. The distributor element then meters flow to the increase pitch line to maintain the desired blade angle.

A speed-sensitive piston governs the distributor element. An increase in speed causes the distributor element to move down to direct pressure to the increase pitch line. A decrease in speed is generally controlled by draining oil from the increase pitch line as the twisting movement

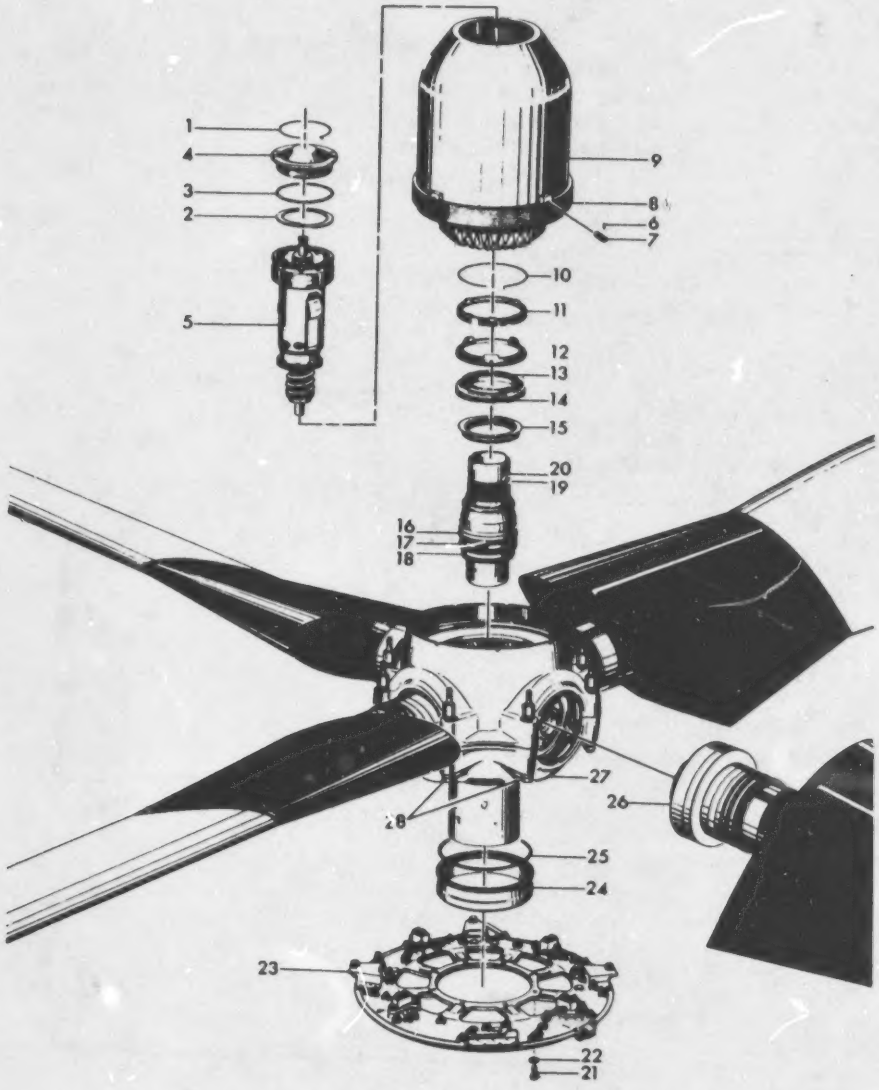

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Figure 10-6.—Propeller assembly (54H60-77).

Nomenclature for Figure 10-6.

1. Retaining ring.
2. Retaining ring.
3. Preformed packing.
4. Dome cap.
5. Low pitch stop assembly.
6. Cotter pin.
7. Fillister head screw.
8. Dome retaining nut.
9. Dome assembly.
10. Retaining ring.
11. Externally threaded ring.
12. Pitchlock control cam.
13. Pin.
14. Stationary pitchlock ring and pin.
15. Externally splined ring spacer.
16. Preformed packing.
17. Preformed packing.
18. Preformed packing.
19. Preformed packing.
20. Pitchlock regular assembly.
21. Socket head bolt.
22. Flat washer.
23. Deicer contact ring holder assembly.
24. Packing ring seat.
25. Preformed packing.
26. Blade assembly.
27. Barrel assembly.
28. Barrel bolts.

of the blade forces the blades to a lower angle. System pressure is also available to the decrease pitch line if upward movement of the distributor element is large enough.

DISASSEMBLY (54H60-77)

A propeller may require disassembly for a complete inspection or replacement of a worn or broken part. Therefore, disassembly procedures will vary from time to time due to the reason for disassembly.

NOTE: The mating location of various parts of the propeller is indicated either by a stamped number or index marks to identify their installation positions. During disassembly check all numbers and index markings for obliterations and if necessary, reidentify to facilitate reassembly.

The 54H60-77 propeller (fig. 10-6) discussed in the following paragraphs is considered to be removed from the aircraft and secured on an assembly and balance bushing.

NOTE: In the following disassembly discussion the function of each component is described as the component is removed.

Remove the dome cap (4). Prior to removal of the low pitch stop assembly (5), a partial disassembly must be accomplished by removing the fluid transfer tube, retaining ring, externally threaded ring, and the keyed washer. Remove the low pitch stop assembly.

The low pitch stop assembly is located inside the dome and its function is to set the desired mechanical low blade angle. Application of sufficiently high inboard pressure actuates this mechanism to remove three stop levers from the piston lever sleeve latch and thus allow the piston to move further outboard, turning the blades toward reverse. This actuating pressure flows from between the outside diameter of the fluid transfer tube and the inside of the servo shaft to the servo valve, which opens at a predetermined pressure level allowing pressure oil into the servo piston chamber. When the servo piston, which is attached to the servo shaft, moves forward it moves the shaft which in turn contacts the stop lever wedge and moves it forward. The stop levers then collapse inwardly to allow the dome piston to move forward and thus move the blades below the stop.

Loosen the dome retaining nut (8) and lift the dome assembly (9) clear of the propeller.

The dome mounts on the barrel shelf and is retained by the dome nut, bearing on an aluminum ring which in turn bears on the flange of the dome shell. The main components of this blade pitch changing mechanism are: rotating cam, stationary cam, piston, and dome shell.

The rotating and stationary cams are assembled as one unit by the use of ball bearing assemblies and a bearing retaining nut so that the rotating cam is free to turn within the stationary cam. The stationary cam splines engage the splines on the inside of the barrel to hold it in place. The piston is attached to the cam assembly by roller bearing assemblies that pass through the outer wall of the piston through the five diagonally opposed cam slots and into the inner wall of the double walled piston. When the dome shell is placed over this group it contains the hydraulic pressures which act on either side of the piston to move it longitudinally within the shell. Since the stationary cam is fixed and the rotating cam cannot move longitudinally, the travel of the piston is transmitted into rotational movement of the rotating cam by the diagonally opposed cam tracks. Teeth on the inboard end of the rotating cam mesh with those of the segmental gears, which are connected to the blade butt, thereby rotating the blades.

NOTE: Always install a dust cover on the inboard end of the dome assembly as soon as

possible after removal and prior to handling or storage.

Remove the externally threaded ring (11). Remove the externally splined spacer ring (15) by installing two threaded screws (No. 5 (0.125) -40NC2A) into the tapped holes in the ring and remove the ring. Remove the pitchlock regulator (20).

The pitchlock regulator is located within the propeller retaining nut assembly and is secured in position by an external splined ring spacer, stationary pitchlock ratchet and pin, and locking control cam, all of which are locked in place by an externally threaded ring and its retaining ring.

The purpose of the pitchlock regulator assembly in addition to that of directing operating oil to the outboard and inboard sides of the piston in the dome assembly is to restrain the amount of overspeeding of the engine-propeller unit should there be an overspeed condition. The regulator does this by actuating a ratchet secured to the rotating cam, causing it to mesh with a stationary ratchet splined to the barrel, thus preventing further blade angle decrease. This actuation occurs at an overspeed condition of 3 to 3 1/2 percent above normal speed or if there is loss of oil pressure. The propeller then operates as in fixed pitch. Rotation into higher blade angles may be made at all times for feathering or regain of control.

A partial disassembly of the barrel assembly (27) must be accomplished in order to remove the blade assemblies (26). Remove the barrel bolts (28) and lift the front barrel half while supporting the blade assemblies at the tips. Install blade butt caps as soon as possible after removal of the blade from the barrel assembly.

The barrel assembly retains the blades, supports the integral oil control assembly, secures the propeller to the engine shaft, and transmits engine torque to the propeller.

The barrel is a split type design. The two sections are manufactured and balanced as a pair and kept together throughout the service life of the propeller. The high centrifugal blade loads are carried by shoulders at each blade bore and a lip outboard of the shoulders secures the blade sealing packings and packing retaining washers.

An extension which is machined integral with the rear barrel half contains splines and seats for the front and rear cones for securing the propeller on the engine propeller shaft. A propeller retaining nut locks the assembly on the shaft.

The propeller retaining nut has a flange on its inboard end which butts against the front cone. The stationary ratchet is secured by a nut locked by a snapring.

The blades are made oiltight within the barrel by synthetic rubber packings which fit inboard of the packing lip of the barrel. The blade packings are prevented from rotating by packing washers which have two pins that extend into grooves in the barrel.

Eight internally relieved stud extensions are installed on the barrel bolt threaded ends to provide attachment points for the spinner.

ASSEMBLY

After determining the proper shims to be used and the blades have been indexed in accordance with existing instructions the propeller may be assembled.

The assembly procedures are the reverse of the disassembly procedures. Install the blades into the rear barrel half using the proper lifting clamp. Install the front barrel half and the barrel bolts. Reassemble the dome and install it in the barrel assembly. Install the deicer contact ring holder assembly and packing ring seat.

When assembly is complete and prior to checking the balance of the propeller, the blades should be tracked. All blades of the 54H60-77 propeller must track within 0.406 inch.

PROP BALANCE

All balancing is accomplished with the dome installed. Detailed instructions for preparation and preliminary balancing are outlined in the Technical Manual Overhaul Instructions for Variable Pitch Aircraft Propeller, Model Number 54H60-77, NavAir 03-CBBK-2 (latest revision).

Preliminary balancing is accomplished with the propeller installed/suspended on the balancing stand. Place balance washers on the shank of the light blades adjacent to the outboard electric contact rings. Preliminary balancing has been obtained when the propeller shows no persistent tendency to tilt.

After determining the amount of washers to install, remove the propeller from the balancing stand. Disassemble the propeller until the light blades have been removed. Install the required washers on the blade balance plugs, but do not exceed the maximum limit allowed.

Reassemble the propeller and reinstall it on the balancing stand. Recheck the preliminary balance.

Prior to attempting the final balancing procedures, the following must be checked:

Feather reverse stop ring setting.
Blade angle adjustment.
Barrel sealing.

The final balance is obtained by adding bolts, washers, and nuts to the balancing holes in the deicer contact ring holder assembly near the outer edge.

Final balance is obtained with the propeller assembly mounted on the horizontal balance machine, with the dome assembly installed and the plane of the blades horizontal. The machine sensitivity must be calibrated so that any balance shown by the machine may be corrected or reversed by applying a restraining moment of 6 ounce-inches.

If final balance cannot be obtained because of the maximum limit on the number of bolts, washers, and nuts which may be added to the deicer contact ring holder assembly, it is necessary to recheck the preliminary balance and correct it to acquire final balance.

RIGGING AND ADJUSTING (54H60-77)

Whenever a propeller, fuel control, coordinator, or fuel control to coordinator linkage has been replaced, or at the initial installation of an engine, a complete check of linkage settings must be made. Final propeller control linkage check and rigging must be accomplished with the propeller installed. The rigging procedure, for a single propeller control linkage installed on a P-3A aircraft is discussed in the following paragraphs.

NOTE: Throughout the rigging procedures the propeller control assembly must remain against the stop. This is accomplished by hanging a 25-pound weight (minimum) on the right side of the control assembly.

Rotate the coordinator propeller setting lever to the 90-degree (takeoff) stop. The coordinator pointer should read 90 degrees; reposition the pointer on the shaft if necessary. The coordinator emergency input lever must be in the full clockwise (unfeather) position. Rotate the coordinator propeller setting lever to 34 degrees (flight idle), and insert a rig pin in the rear lever. (See fig. 10-7 (A).) Adjust the propeller control rear link rod if necessary.

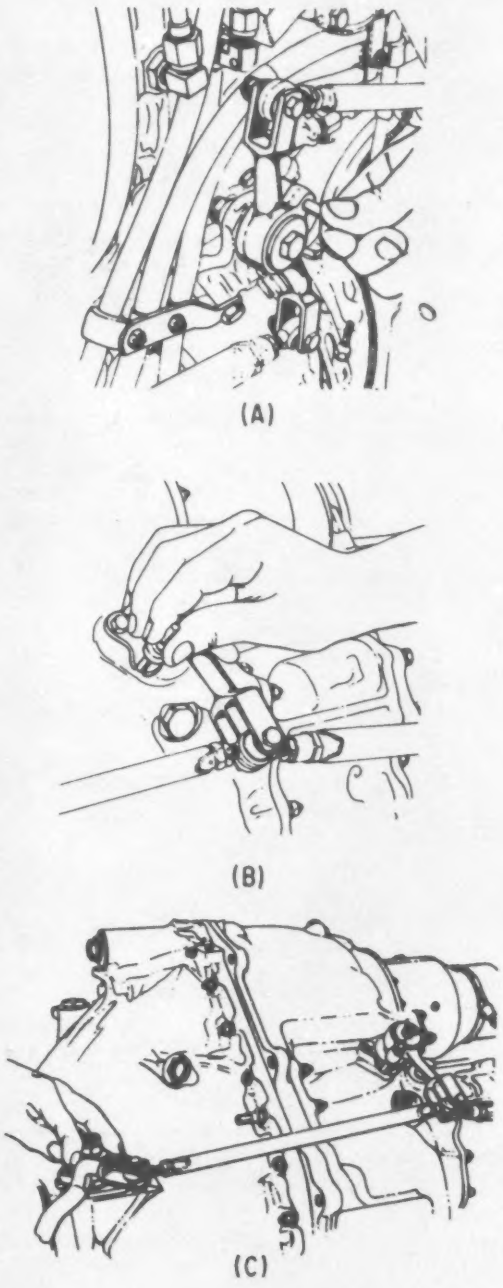

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Figure 10-7.—Inserting rigging pins. (A) In rear lever; (B) in intermediate lever; (C) in forward lever.

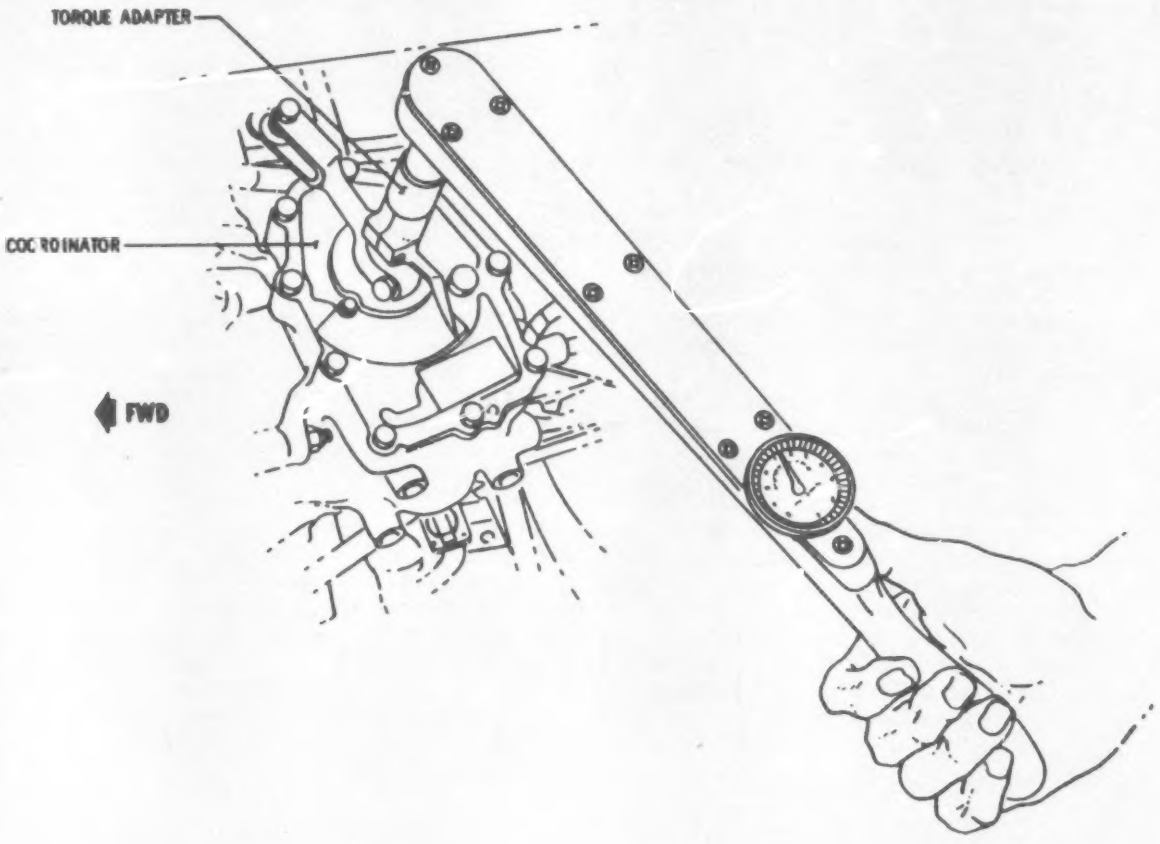

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Figure 10-8.—Checking force required to move propeller control linkage.

Insert a rigging pin in the propeller control intermediate lever. (See fig. 10-7 (B).) Adjust the rear intermediate link rod to the correct length.

Insert a rigging pin in the propeller control forward lever. (See fig. 10-7 (C).) Adjust the link rod between the forward lever and the intermediate lever. At the serrated end of the forward lever, center the serrated spacer in the yoke slot so that adjustment is available in both directions. Adjust the propeller control forward rod until a rigging pin can be inserted in the hole at the flight idle (FI) position on the rigging plate.

NOTE: The propeller control input lever end fitting to the propeller control forward lever clevis must be the spherical type, not the double row ball bearing type which is widely used elsewhere on the engine. Excess angular movement will cause loss of the ball bearings if the latter type is used in this specific location.

Remove all the rigging pins from the levers. With the coordinator emergency input lever in the UNFEATHER position, move the coordinator propeller setting lever to the 0-degree, 34-degree, and 90-degree positions, then rotate the coordinator emergency input lever to the FEATHER position. At each of these settings, the rigging pin must be easily inserted in the hole at reverse (REV), flight idle (FI), takeoff (TO), and feather (FEA) positions, respectively,

on the control input indexing plate. If the rigging pin does not align at all points, make the following adjustments:

To change the total travel, move the serrated spacer to the end of the propeller control forward lever. Moving the spacer out, decreases total travel; moving the spacer in, increases total travel.

To align the rigging pin hole to the rigging plate slots, adjust the length of the propeller forward rod. Repeat these adjustments until all points are within limits. When checking the 34-degree position, it must be possible to insert a rigging pin in the propeller control forward lever.

After all rigging has been completed, check for installation of bolts, nuts, and safetywire. Torque all bolts and nuts and safetywire all rod ends in accordance with the appropriate technical manual.

Install a coordination control shaft torque adapter on the main coordinator main shaft spline. Using a torque wrench, move the linkage through its full travel. (See fig. 10-8.) Torque must not exceed 17 inch-pounds at any point of travel. If the indicated torque exceeds these limits, inspect the linkage and eliminate the cause of binding or dragging.

TROUBLESHOOTING

As previously stated in this training manual, troubleshooting may be defined as the systematic and thorough analysis of the symptoms of engine malfunctioning. This also applies to propellers. Therefore, it is essential that Aviation Machinist's Mates know the propeller as thoroughly as possible. They should know what it is designed to do and how it fulfills this function. They should be familiar with normal operating details of the propeller, such as feather and unfeather procedures, reversing procedures, etc.

Table 10-1 covers some of the troubles, along with the probable causes and remedies of a 54H60-77 propeller installed on a P-3A aircraft.

NOTE: Troubleshooting information similar to that contained in table 10-1 is available in Maintenance Instructions Manuals for all aircraft. If information of the type contained in these tables is followed, it will be productive of the most efficient maintenance, that is, it will aid in recognizing abnormalities of the equipment and tracing them to their sources and making corrections before damage is done.

Table 10-1.—Propeller troubleshooting chart.

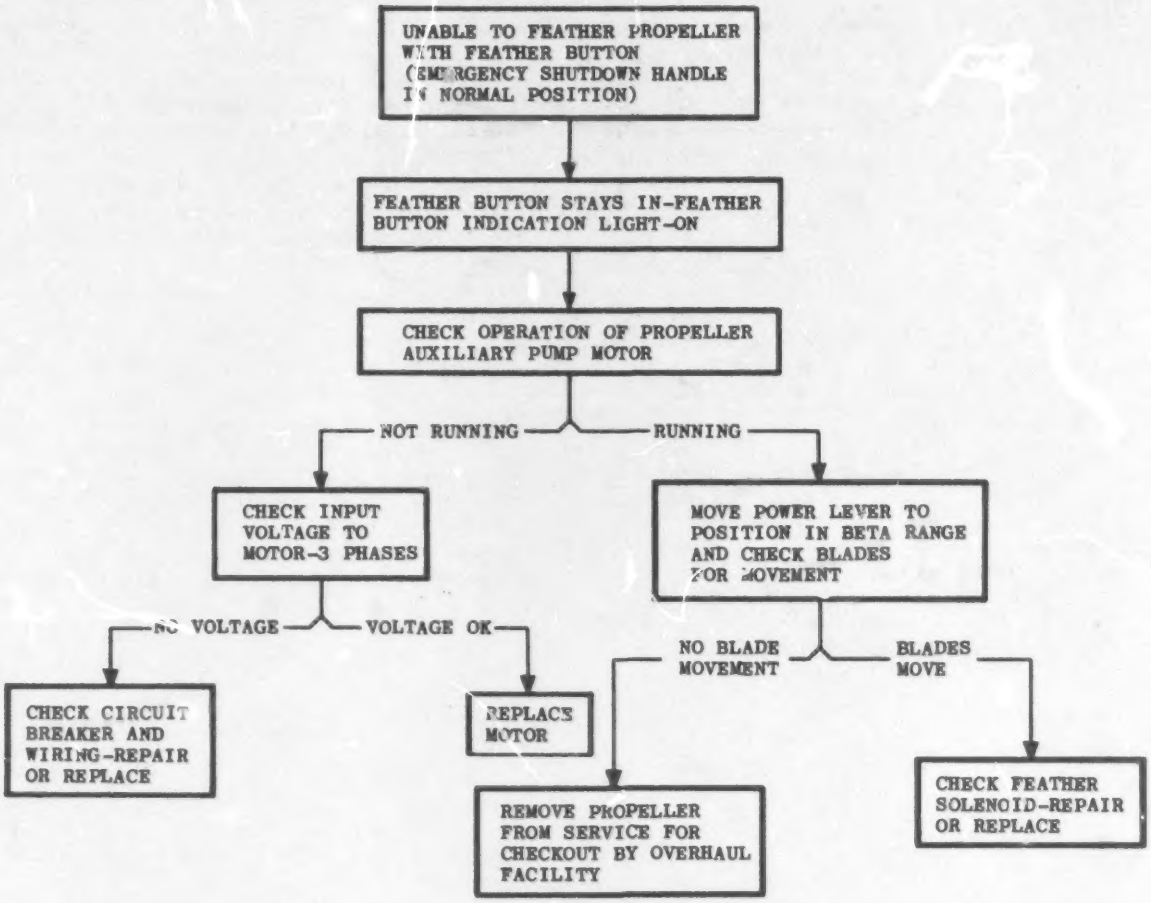

UNABLE TO FEATHER PROPELLER WITH FEATHER BUTTON (EMERGENCY SHUTDOWN HANDLE IN NORMAL POSITION)
FEATHER BUTTON STAYS IN-FEATHER BUTTON INDICATION LIGHT-ON
CHECK OPERATION OF PROPELLER AUXILIARY PUMP MOTOR
NOT RUNNING
RUNNING
CHECK INPUT VOLTAGE TO MOTOR-3 PHASES
MOVE POWER LEVER TO POSITION IN BETA RANGE AND CHECK BLADES FOR MOVEMENT
NO VOLTAGE
VOLTAGE OK
NO BLADE MOVEMENT
BLADES MOVE
CHECK CIRCUIT BREAKER AND WIRING-REPAIR OR REPLACE
REPLACE MOTOR
REMOVE PROPELLER FROM SERVICE FOR CHECKOUT BY OVERHAUL FACILITY
CHECK FEATHER SOLENOID-REPAIR OR REPLACE

Table 10-1.–Propeller troubleshooting chart–Continued.

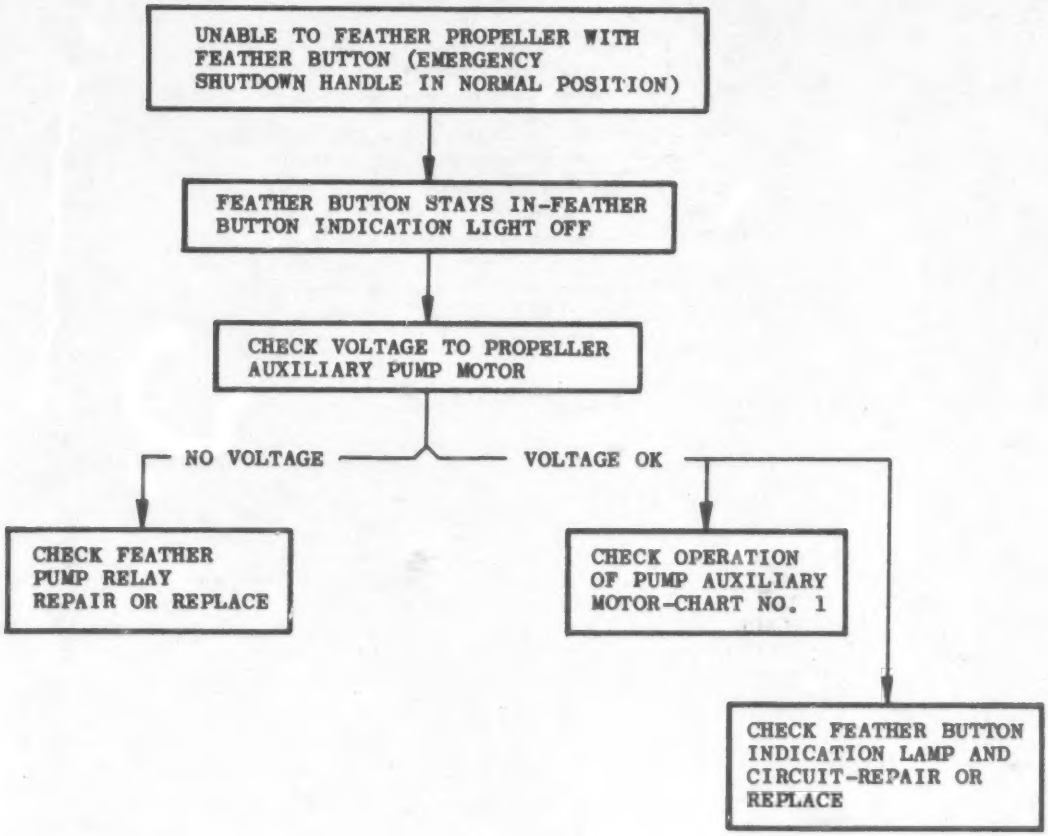

UNABLE TO FEATHER PROPELLER WITH FEATHER BUTTON (EMERGENCY SHUTDOWN HANDLE IN NORMAL POSITION)
FEATHER BUTTON STAYS IN-FEATHER BUTTON INDICATION LIGHT OFF
CHECK VOLTAGE TO PROPELLER AUXILIARY PUMP MOTOR
NO VOLTAGE
VOLTAGE OK
CHECK FEATHER PUMP RELAY REPAIR OR REPLACE
CHECK OPERATION OF PUMP AUXILIARY MOTOR-CHART NO. 1
CHECK FEATHER BUTTON INDICATION LAMP AND CIRCUIT-REPAIR OR REPLACE

Table 10-1.—Propeller troubleshooting chart—Continued.

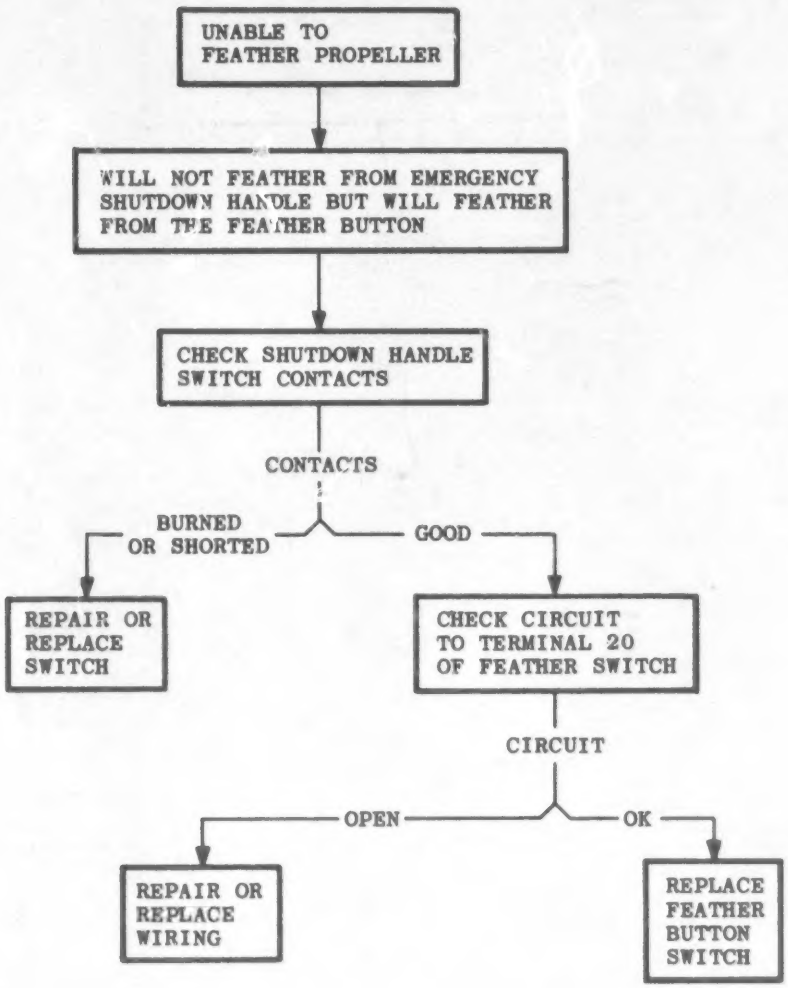


Table 10-1.–Propeller troubleshooting chart–Continued.

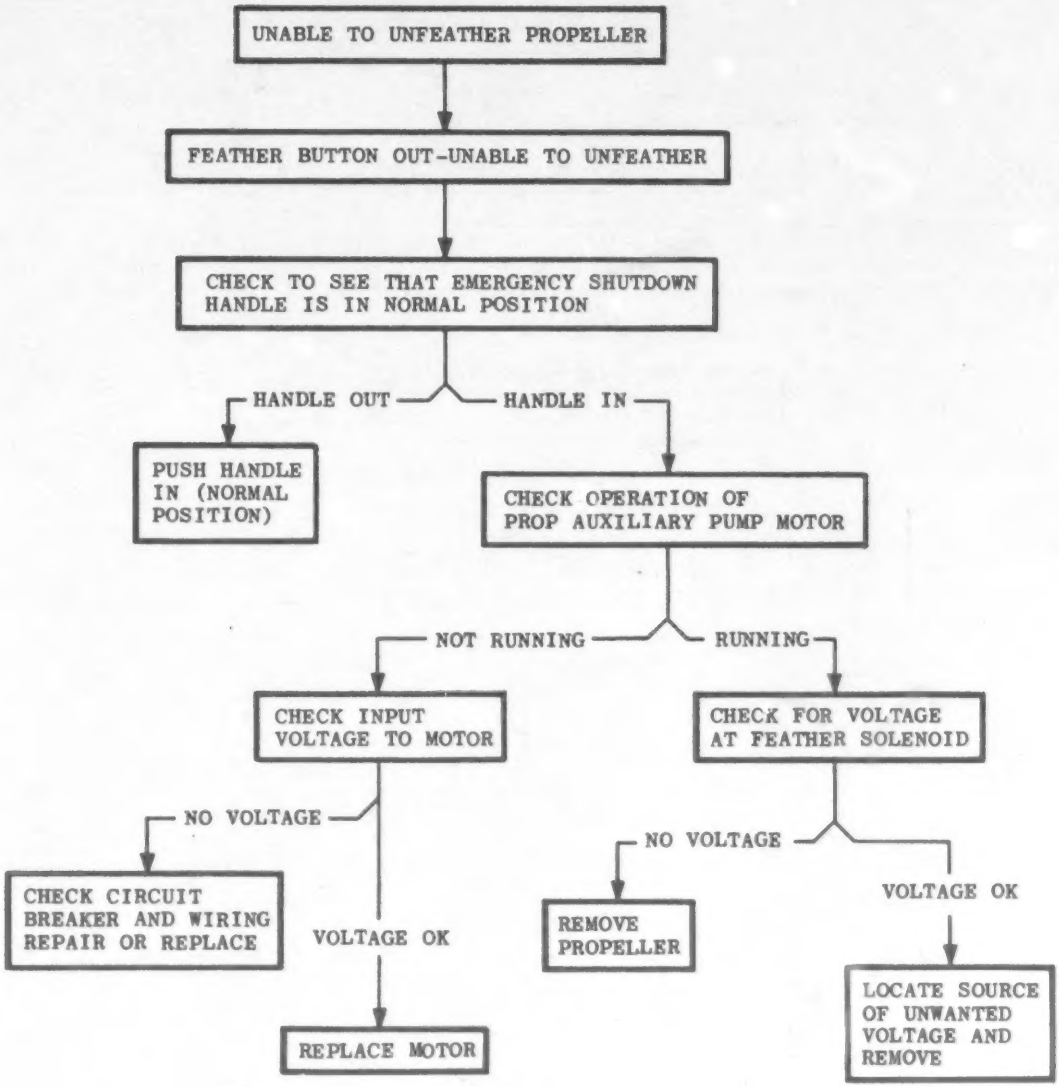

UNABLE TO UNFEATHER PROPELLER
FEATHER BUTTON OUT-UNABLE TO UNFEATHER
CHECK TO SEE THAT EMERGENCY SHUTDOWN HANDLE IS IN NORMAL POSITION
HANDLE OUT
HANDLE IN
PUSH HANDLE IN (NORMAL POSITION)
CHECK OPERATION OF PROP AUXILIARY PUMP MOTOR
NOT RUNNING
RUNNING
CHECK INPUT VOLTAGE TO MOTOR
CHECK FOR VOLTAGE AT FEATHER SOLENOID
NO VOLTAGE
NO VOLTAGE
VOLTAGE OK
CHECK CIRCUIT BREAKER AND WIRING REPAIR OR REPLACE
VOLTAGE OK
REMOVE PROPELLER
LOCATE SOURCE OF UNWANTED VOLTAGE AND REMOVE
REPLACE MOTOR

Table 10-1.—Propeller troubleshooting chart—Continued.

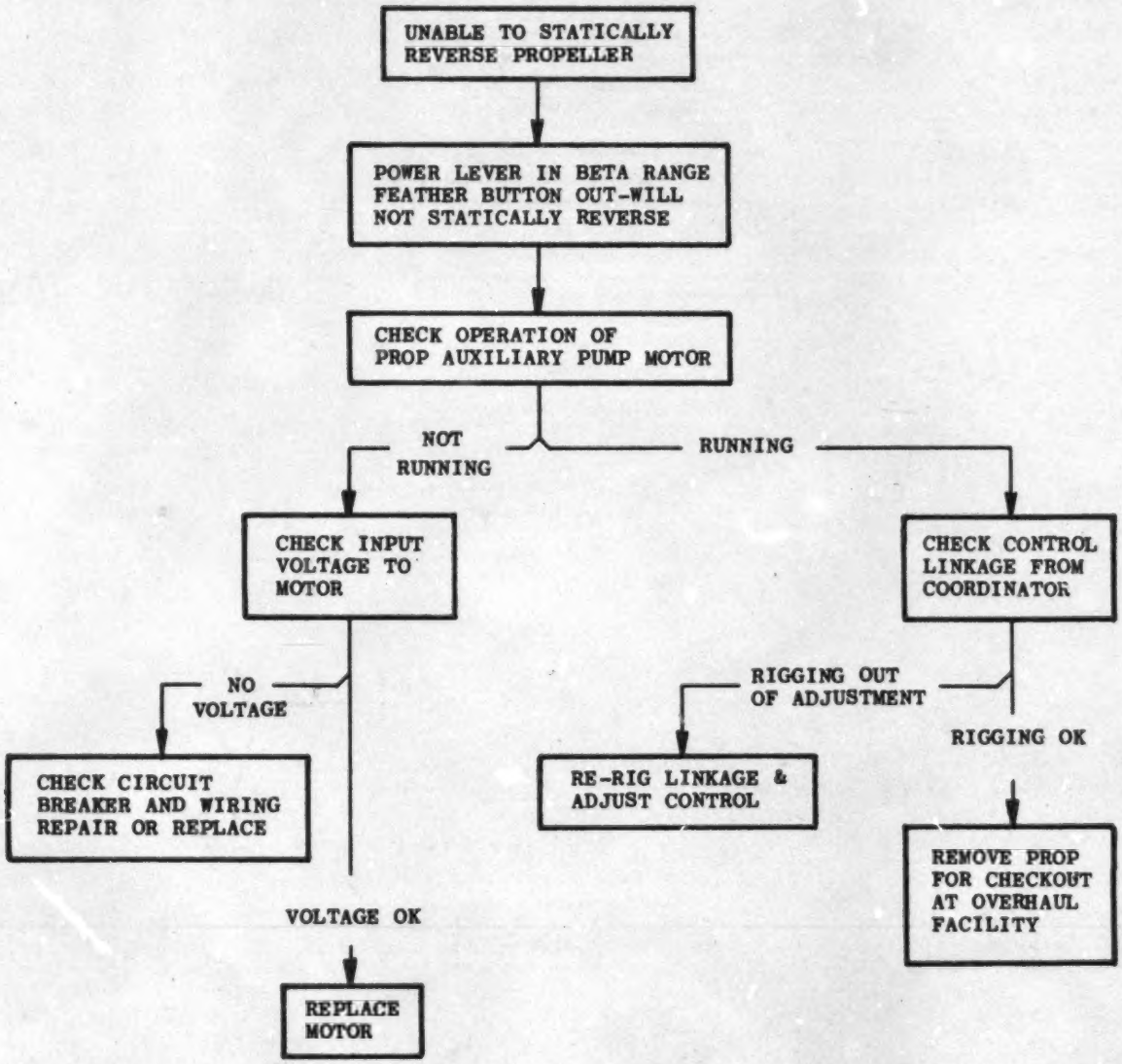

UNABLE TO STATICALLY REVERSE PROPELLER
POWER LEVER IN BETA RANGE FEATHER BUTTON OUT-WILL NOT STATICALLY REVERSE
CHECK OPERATION OF PROP AUXILIARY PUMP MOTOR
NOT RUNNING
RUNNING
CHECK INPUT VOLTAGE TO MOTOR
CHECK CONTROL LINKAGE FROM COORDINATOR
NO VOLTAGE
RIGGING OUT OF ADJUSTMENT
RIGGING OK
CHECK CIRCUIT BREAKER AND WIRING REPAIR OR REPLACE
RE-RIG LINKAGE & ADJUST CONTROL
REMOVE PROP FOR CHECKOUT AT OVERHAUL FACILITY
VOLTAGE OK
REPLACE MOTOR

Table 10-1.—Propeller troubleshooting chart—Continued.

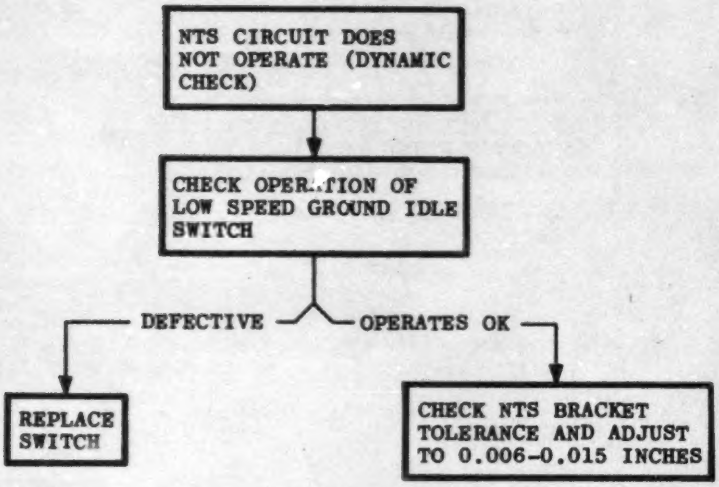
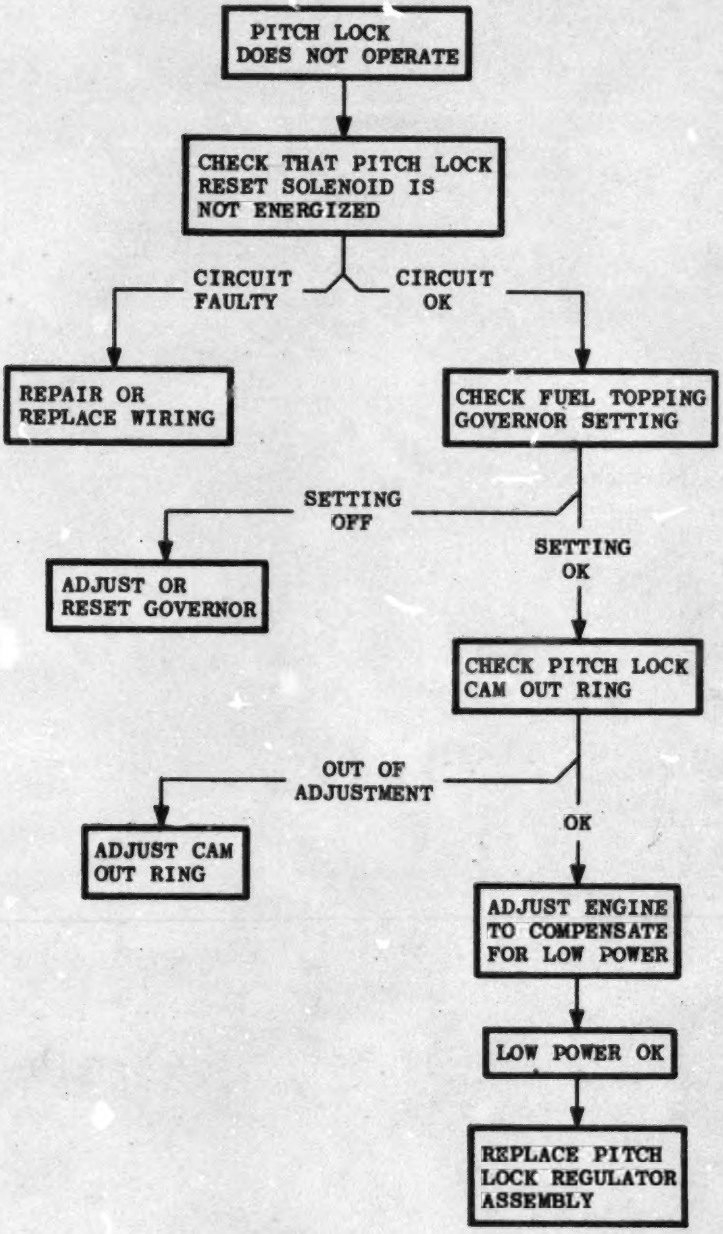

NTS CIRCUIT DOES NOT OPERATE (DYNAMIC CHECK)
CHECK OPERATION OF LOW SPEED GROUND IDLE SWITCH
DEFECTIVE
OPERATES OK
REPLACE SWITCH
CHECK NTS BRACKET TOLERANCE AND ADJUST TO 0.006-0.015 INCHES

Table 10-1.—Propeller troubleshooting chart—Continued.


PITCH LOCK DOES NOT OPERATE
CHECK THAT PITCH LOCK RESET SOLENOID IS NOT ENERGIZED
CIRCUIT FAULTY
CIRCUIT OK
REPAIR OR REPLACE WIRING
CHECK FUEL TOPPING GOVERNOR SETTING
SETTING OFF
SETTING OK
ADJUST OR RESET GOVERNOR
CHECK PITCH LOCK CAM OUT RING
OUT OF ADJUSTMENT
OK
ADJUST CAM OUT RING
ADJUST ENGINE TO COMPENSATE FOR LOW POWER
LOW POWER OK
REPLACE PITCH LOCK REGULATOR ASSEMBLY

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